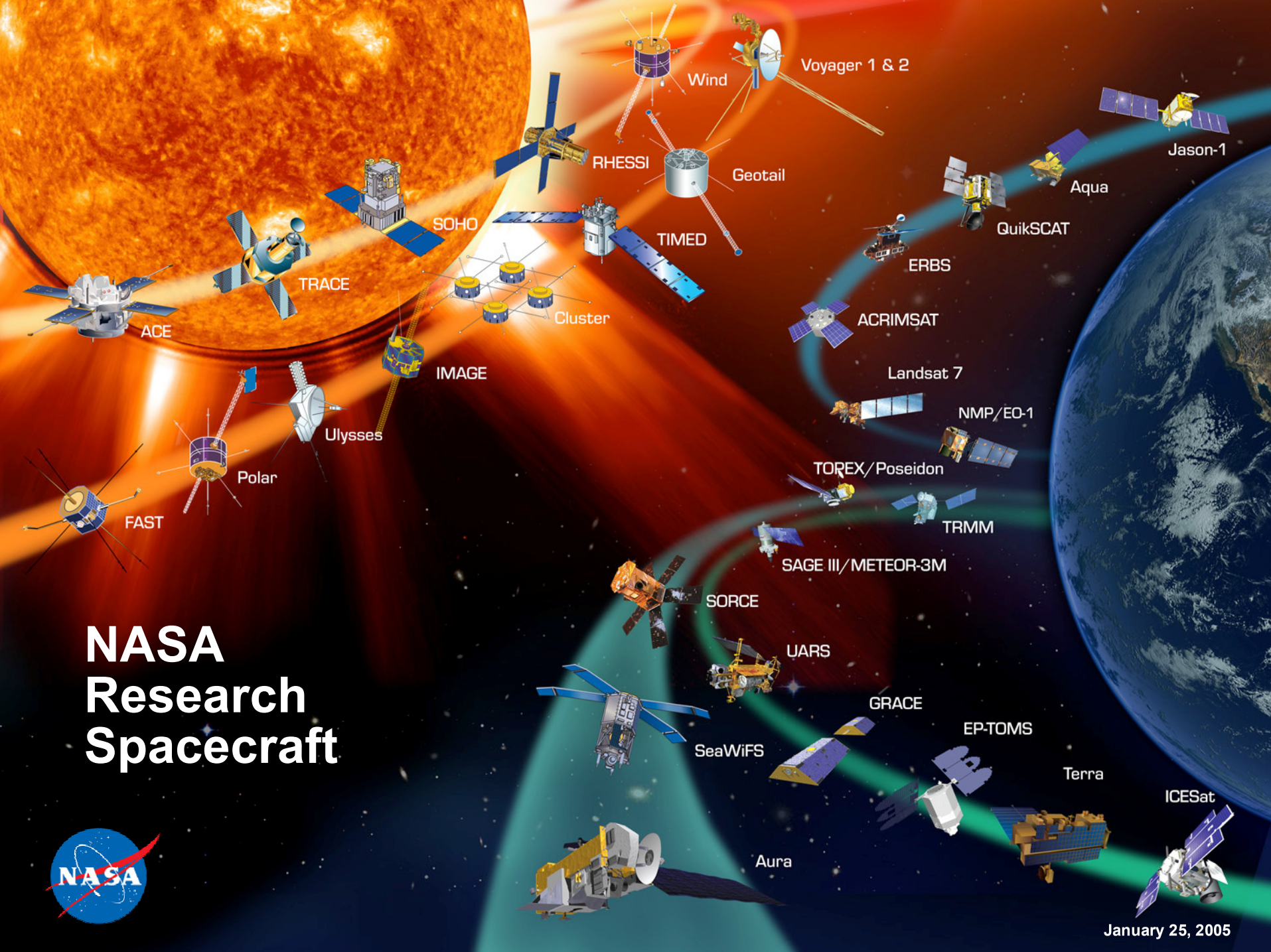
NASA Science and Space Systems benefiting Society

SENH Workshop

Sioux Falls, South Dakota
EROS Data Center
May 3-5, 2005

Stephen D. Ambrose
Applied Sciences Program
NASA Science Mission Directorate

The NASA Vision
To improve life here,
To extend life to there,
To find life beyond.
The NASA Mission
To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.
January 25, 2005


NASA
Research
Spacecraft
Wind
Voyager 1 & 2
RHESSI
Geotail
SOHO
TIMED
TRACE
ACE
Cluster
IMAGE
Ulysses
Polar
FAST
Jason-1
Aqua
QuikSCAT
ERBS
ACRIMSAT
Landsat 7
NMP/EO-1
TOREX/Poseidon
TRMM
SAGE III/METEOR-3M
SORCE
UARS
GRACE
EP-TOMS
SeaWiFS
Terra
ICESat
Aura
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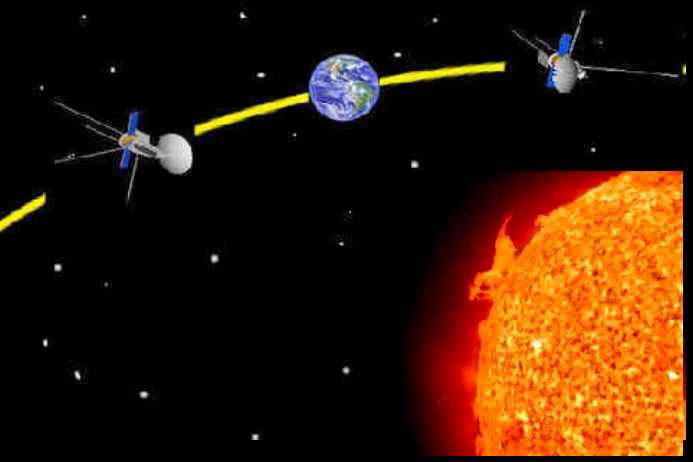
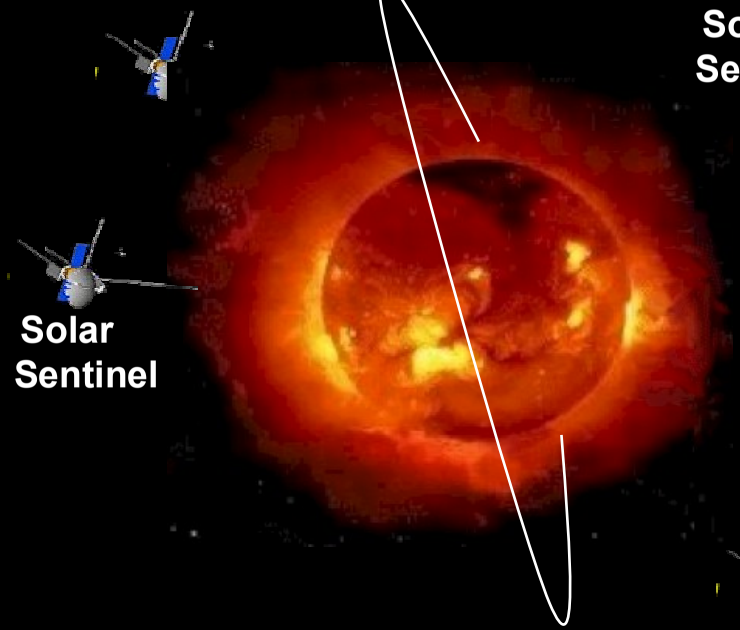
Sun-Earth Connection
Research Question



How are the Sun, heliosphere, and planets connected in a single system?



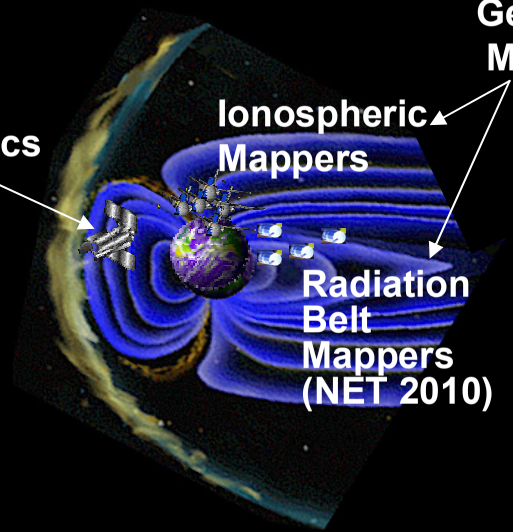
Solar Sentinel

Solar Sentinel

Solar Dynamics Observatory

(2008)

Solar Sentinel (NET 2013)



Geospace Missions

Ionospheric Mappers

Radiation Belt Mappers (NET 2010)

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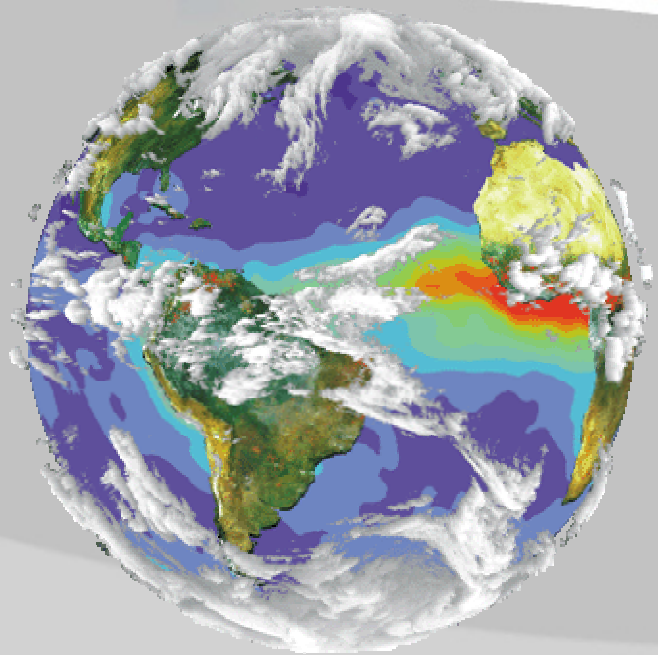
Planet Earth - a Dynamic System

Forces acting on the Earth system



Earth system responses

IMPACTS

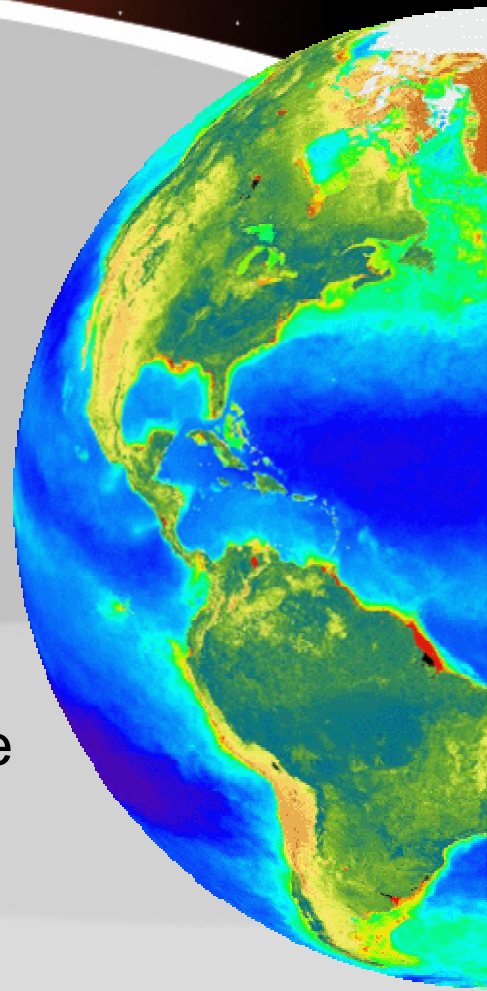
Feedbacks

Of the total forcing of the climate system, 40% is due to the direct effect of greenhouse gases and aerosols, and 60% is from feedback effects, such as increasing concentrations of water vapor as temperature rises.

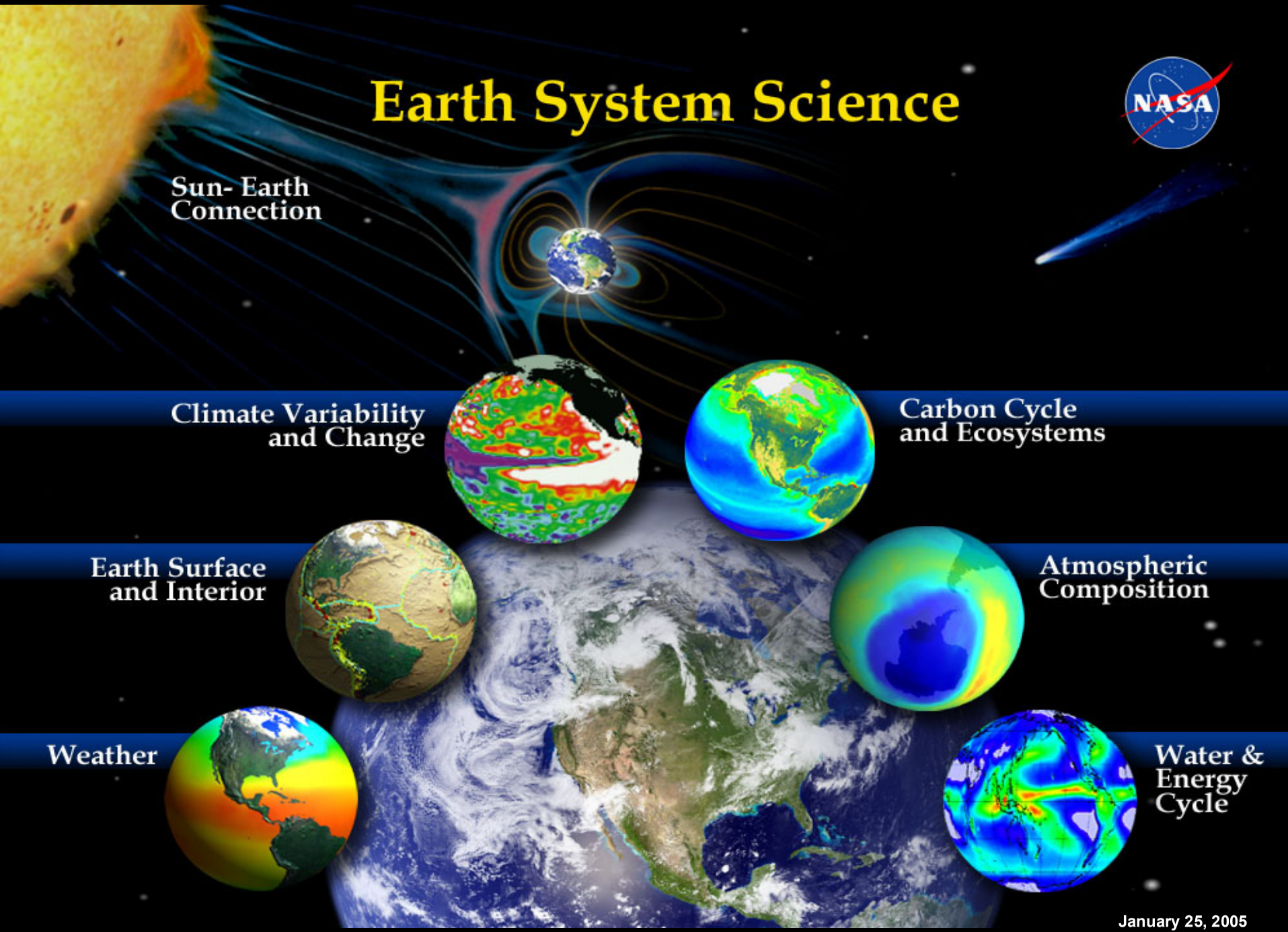
Earth System Science Research Questions

How is the Earth changing and what are the consequences of life on Earth?

- How is the global Earth system ***changing***?
- What are the primary **forcings** of the Earth system?
- How does the Earth system ***respond*** to natural and human-induced changes?
- What are the ***consequences*** of changes in the Earth system for human civilization?
- How well can we ***predict*** future changes in the Earth system?



Earth System Science



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Data Acquisition to Data Access

Data Acquisition

Flight Operations, Data Capture, Initial Processing & Backup Archive

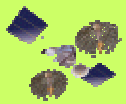
Data Transport to DAACs

Science Data Processing, Data Mgmt., Data Archive & Distribution

Distribution, Access, Interoperability & Reuse

Spacecraft

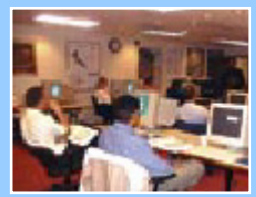
Tracking & Data Relay Satellite (TDRS)



Ground Stations

Polar Ground Stations

Data Processing & Mission Control



NASA Integrated Services Network (NISN) Mission Services

EOSDIS Science Data Systems (DAACs)

REASoNs

WWW IP Internet

Science Teams

Measurement Teams

Research

Education

Value-Added Providers

Interagency Data Centers

International Partners

Use in Earth System Models

Benchmarking DSS

TECHNOLOGY

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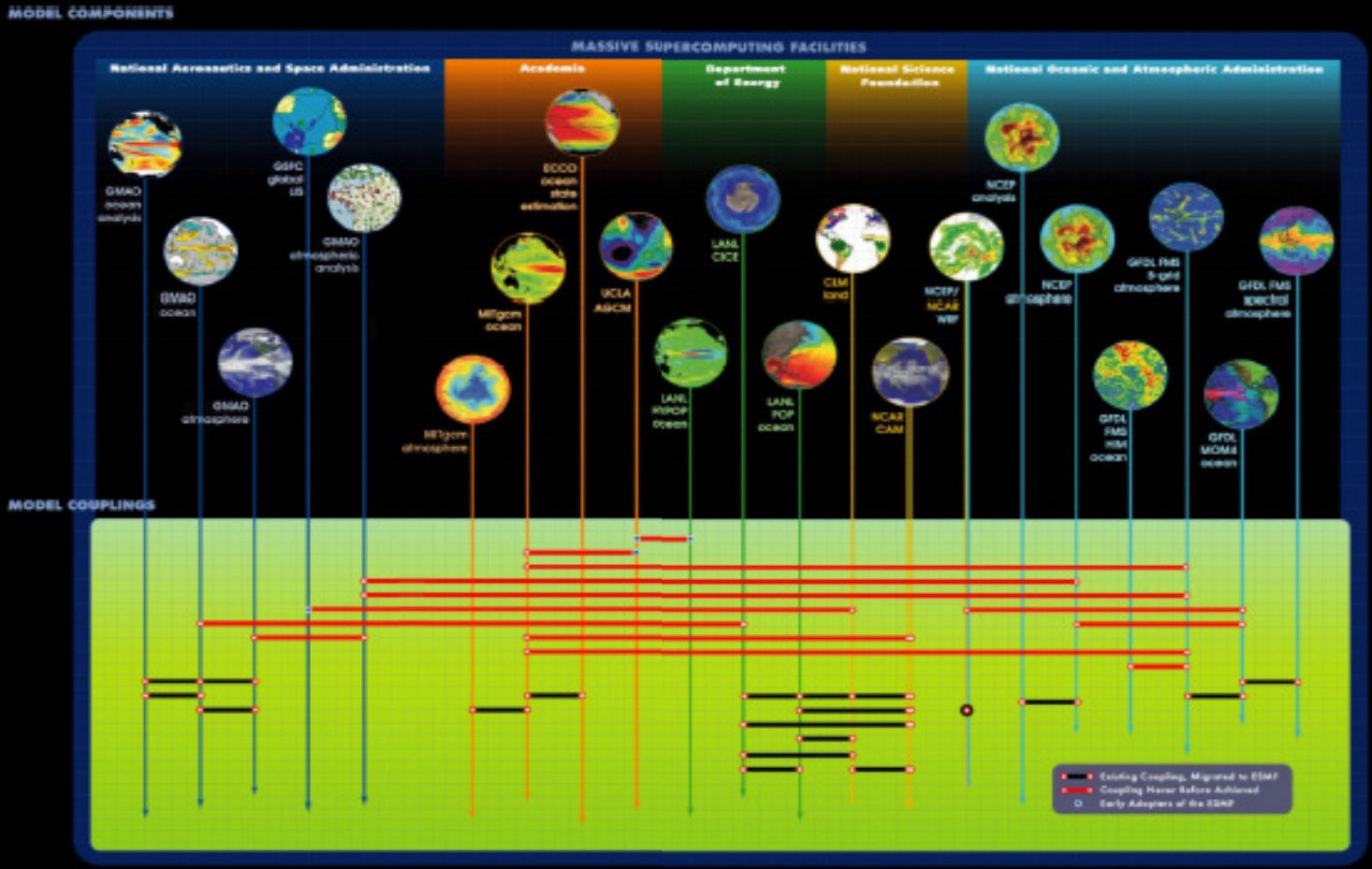
Earth System Models

EARTH SYSTEM MODELING FRAMEWORK



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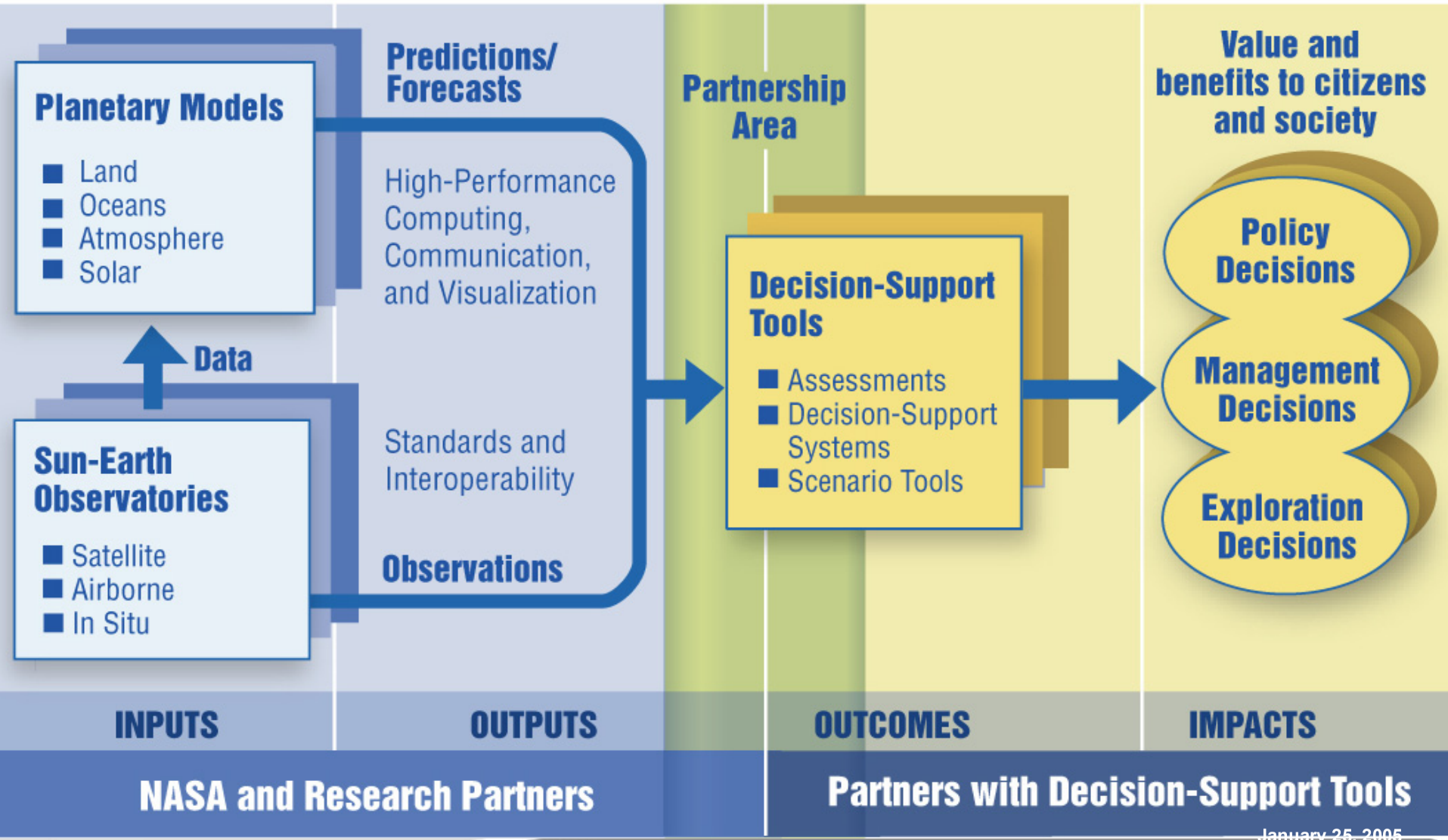
Integrating Knowledge, Capacity and Systems into Solutions



National Application	Partner Organizations	Decision-Support Systems
Agricultural Efficiency	USDA,NOAA	CADRE—Crop Assessment Data Retrieval and Evaluation (USDA)
Air Quality	EPA,NOAA,USDA	CMAQ—Community Multiscale Air Quality Modeling System AIRNow AQI—Air Quality Index
Aviation	DOT/FAA,NOAA	NAS-AWRP—National Air Space-Aviation Weather Research Program
Carbon Management	USDA,DOE,NOAA	CQUEST—Support to the Energy Act of 1992,Section 1605b
Coastal Management	NOAA,EPA,NRL	HAB—Harmful Algal Bloom Bulletin/Mapping System CREWS—Coral Reef Early Warning System
Disaster Management	DHS/FEMA,NOAA,USGS,USFS	AWIPS—Advanced Weather Interactive Processing System HAZUS-MH—Hazards U.S.—Multi-Hazards
Ecological Forecasting	USAID,NOAA,NPS,CCAD,USGS	SERVIR—Regional Visualization and Monitoring System
Energy Management	DOE,UNEP,NOAA,NRC	RETScreen—Energy Diversification Research Laboratory (CEDRL) NEMS—National Energy Modeling System
Homeland Security	DHS,USGS,NOAA,NGA,DOD	IOF—Integrated Operations Facility IMAAC—Interagency Modeling and Atmospheric Assessment Center
Invasive Species	USGS,USDA,NOAA	ISFS—Invasive Species Forecasting System
Public Health	NIH,CDC,DOD,EPA	PSS—Plague Surveillance System EPHTN—Environmental Public Health Tracking Network MMS—Malaria Monitoring and Surveillance RSVP—Rapid Syndrome Validation Project
Water Management	EPA,USDA,USGS,BoR	RiverWARE—Bureau of Reclamation decision-support Tool AWARDS—Agricultural Water Resources and decision-support Tool BASINS—Better Assessment Science Integrating Point and Nonpoint Source

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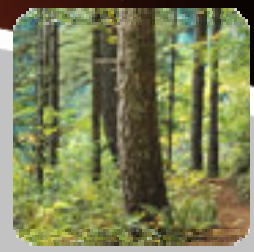
Applications of National Priority

Agricultural Efficiency

Air Quality

Aviation



Carbon Management

Coastal Management

Disaster Management

Ecological Forecasting

Energy Management

Homeland Security

Invasive Species

Public Health

Water Management

Agricultural Efficiency

Integrated System Solution

EARTH SYSTEM MODELS

- Agricultural Meteorological Model: *AGRMET*
- 2 Layer Soil Moisture Models:
- Crop Models: *CERES, AGRISTARS, Mass, URCROP, Sinclair*

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- Land: *Aqua, Terra, Landsat 7,* SRTM, TOPEX, JASON-1, *NPP, NPOESS, HYDROS*
- Atmosphere: *TRMM, OCO, GPM*
- Ocean: *SeaWIFS, QuikScat, Aqua, Aquarius*

**Future Mission*

Predictions

- 12 Month Global Seasonal Surface Temperature/ Soil Moisture/ Precipitation Forecast
- Crop maturity
- Crop yield
- Water availability

Observations

- Biomass
- Land Cover/ Use
- Land Surface Topography
- Ocean Surface Currents
- Global Precipitation
- Soil Moisture
- Reservoir level
- Evapotranspiration
- Radiation

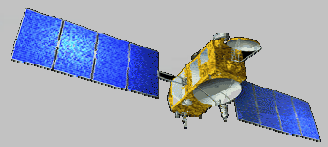
DECISION SUPPORT TOOLS

- **PECAD/CADRE** (**C**rop **A**ssessment **D**ata **R**etrieval **&** **E**valuation)
  - Generated time series graphs for rainfall, temperature , and soil moisture
  - Multi-year time series/ crop comparisons
  - Vegetation anomaly detection
  - Automated web products

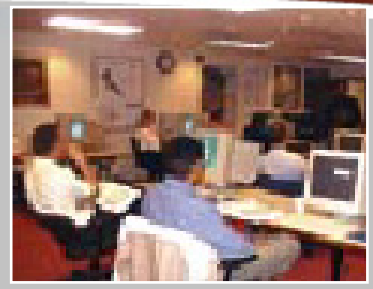
VALUE & BENEFITS

- Early warning of problems in major agricultural commodities
- Reduction in production costs.
- Better seasonal yield estimates
- Early warning of food shortages

Agriculture Efficiency



Tasking

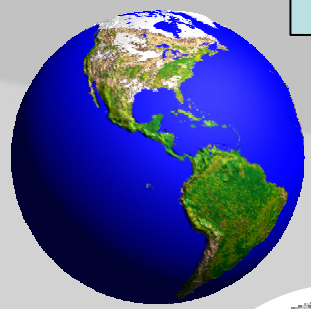


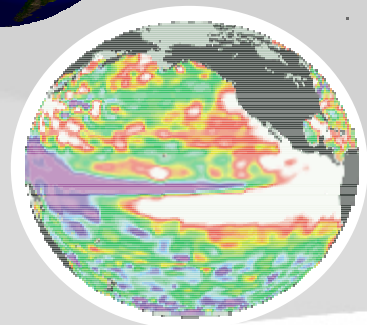
EDOS: Mission Control

Downlink

EOSDIS & DAACs

Exploitation





Societal Benefits

CADRE:
USDA Decision Support System for Global Crop Production Assessments

Air Quality

Integrated System Solution

EARTH SYSTEM MODELS

- **Aerosol Transport:** *GOCART*
- **Global-Regional Assimilations:** *RAQMS*
- **Atmospheric Chemistry:** *GEOS-CHEM*
- **Emissions:** *SMOKE*
- **Meteorology:** *MM5, ETA*
- **Air Trajectories:** *NOAA-Hysplit4*

Predictions

- Atmospheric state parameters
- Global-to-regional concentrations
- Emissions inventories
- Regional-Global transport
- Trace Gas Sources
- Aerosol properties
- Ozone profiles & columns
- Global-regional boundary conditions
- Data fusion techniques
- Ground-satellite data comparison techniques

Data

EARTH OBSERVATORIES

- **Aerosols:** *Terra, Aqua, TOMS, Aura, Aeronet, AIRNow, INTEX, CALIPSO, Glory-APS*
- **Ozone & Precursors:** *TOMS, Aura, SAGE III, AIRNow, INTEX*
- **Trace Gases:** *Terra, Aqua, OCO*
- **Clouds:** *Terra, Aqua, CloudSAT, CALIPSO*
- **Land Use/Cover:** *Terra, Aqua, Landsat*
- **Atmospheric Parameters:** *GOES, POES, GIFTS, NPP, NPOES*

Observations

DECISION SUPPORT TOOLS

CMAQ (**C**ommunity **M**ulit-scale **A**ir **Q**uality modeling system)

- **Assess emissions control strategies**
- **Develop achievable SIPs (State Implementation Plan)**
- **Assess compliance**
- **Waivers to air standards**
- **Quantify voluntary stationary emission reductions**

Inputs: Urban heat island reduction, emissions inventories

AIRNow & AQI (**A**ir **Q**uality **I**ndex)

- **Forecast transport of dust/pollutants**
- **Actions to reduce source emissions**
- **$PM_{2.5}$ forecasts**

International Treaties

VALUE & BENEFITS

- **Reduce lung-related diseases & premature death**
- **Reduce hospital admissions & use of medicines**
- **Reduce lost workdays and schooldays**
- **Improve visibility and reduce haze for tourism**
- **Improve resiliency of crops; increase yields**
- **Increase confidence in government**
- **Improve crop estimates**
- **Sensitive populations can change activities**

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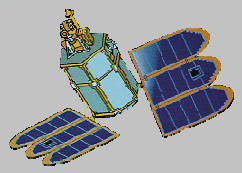
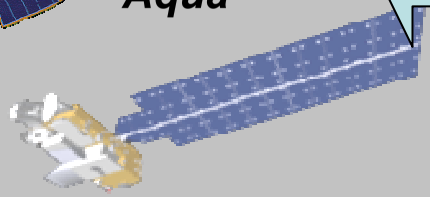
Air Quality

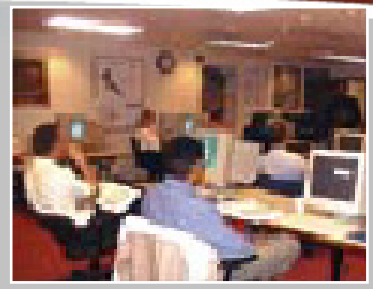
TOMS-EP



Aqua



Tasking

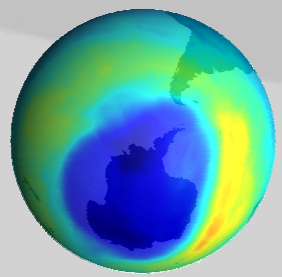


EDOS: Mission Control

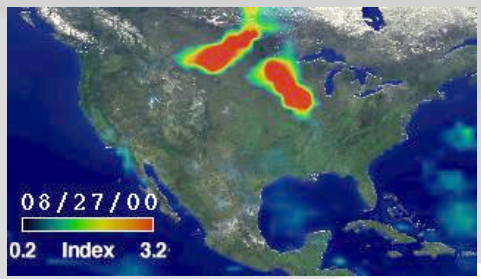
Downlink

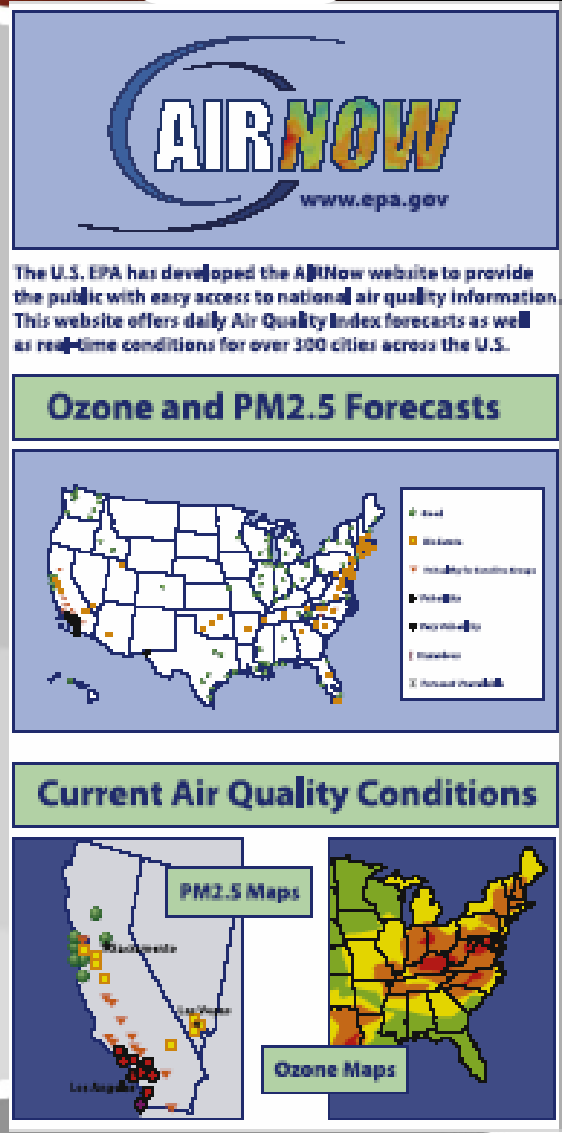
Societal Benefits

Exploitation



EOSDIS & DAACs





Aviation

Integrated System Solution

EARTH SYSTEM MODELS

- **Weather:** *WRF, RUC*
- **Icing:** *FAA CIP, FAA FIP*
- **Convective Weather:** *CIMSS Convective Cloud Mask, FAA NCWF & OCWF*
- **Ceiling/ Visibility:** *FAA NCVP*
- **Turbulence:** *FAA GTG, ITFA*

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

GOES, METEOSAT, GMS, TOMS, TRMM,QuikScat (SeaWinds), Terra, Aqua (MODIS, AIRS)

GIFTS Imager and Sounder

NPP, NPOESS, etc

- *CrIS, IASI, NOAA-series*

Airborne/Field Ex. -- PIREPS, TAMDAR THORPEX, AIRS, IHOP, CRYSTAL

IPO -- NAST, CPL, MAS, Wind Lidars

DOD Assets – GPS, DMSP, IAEAsats

**Future Mission*

Predictions

- Convective Weather
- Turbulence
- Icing
- Ceiling and Visibility
- Volcanic Transport
- Oceanic Winds
- Winter Storms
- Tropical Cyclones

Observations

- Atmospheric Temperature
- Atmospheric Water Vapor
- Atmospheric Winds
- Storm Cell Properties
- Volcanic Gas & Ash
- Cloud Properties
- Global Precipitation

DECISION SUPPORT TOOLS

- **NAS-AWRP** (**N**ational **A**irspace **S**ystem- **A**viation **W**eather **R**esearch **P**rogram)
- Key weather observations
- Nowcasting Products
- 24 Hour precise continuous atmosphere
- Weather warnings and predictions
- Accurate and easily accessible weather forecasts
- Increase in understanding of atmospheric conditions
- Real time interest fields
- Comprehensive image library

Management Decisions

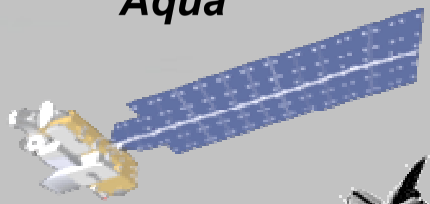
- Routing of Flights
- Turbulence/convective weather avoidance
- Fuel/Landing loads

VALUE & BENEFITS

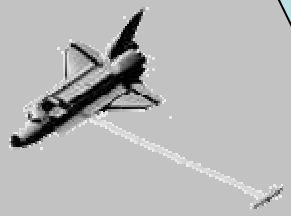
- Improved Safety
- Improved Airline Efficiency
- Earlier warnings of hazardous weather
- Reduction in the cost of flying

Aviation

Aqua



SRTM



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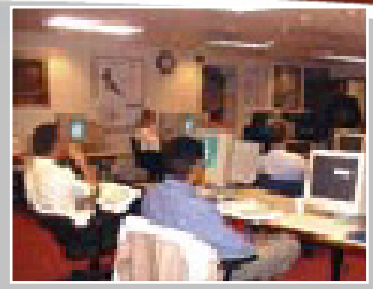
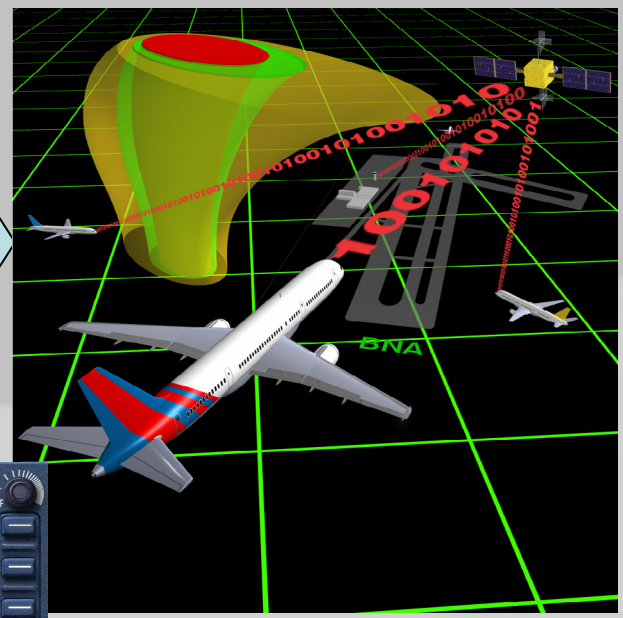


EDOS: Mission Control

Downlink

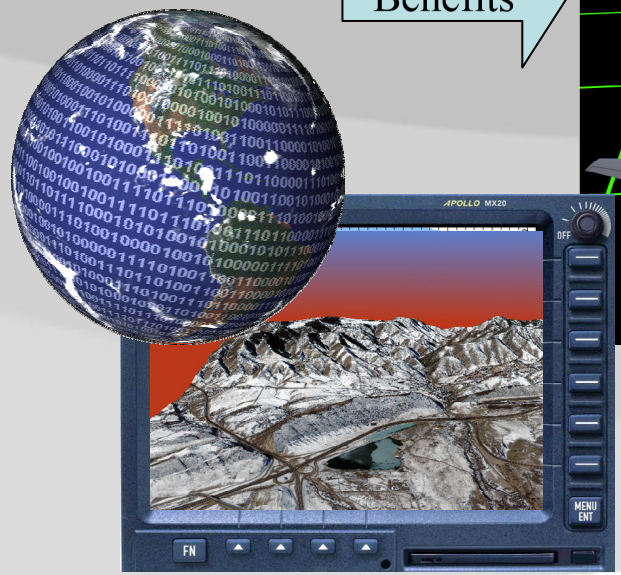
Societal Benefits



Digital Airspace for National Airspace System

Exploitation

EOSDIS & DAACs



Synthetic Vision System display

Coastal Management

Integrated System Solution

EARTH SYSTEM MODELS

- **Global Ocean Circulation Models:** *LANL POP, LANL HYPOP*
- **Coastal Ocean Circulation Models:** *MITgcm, GFDL MOM4, ADCIRC, SHORECIRC*
- **Wind & Wave Models:** *COAMPS, SWAN*
- **Ocean Pattern Models:** *MITgcm, GFDL, HIM*
- **Chlorophyll Models (*regional)***
- **Sea Surface Temperature:** *NSIPP Ocean, ECCO OSE*

Data

EARTH OBSERVATORIES

- **SST & Salinity:** *Terra, Aqua, Aquarius, GOES, NPP, NPOESS*
- **Ocean Winds:** *QuikScat, ADEOS-II, GCOM*
- **Coastal/Land Use:** *Terra, Aqua*
- **Ocean Color:** *Terra, Aqua, NPP, NPOESS, SeaWifFS*
- **Ocean Topography:** *Topex, Jason 1, OSTM*
- **Precipitation:** *TRMM, Aqua*
- **Ocean Circulation:** *Jason, Aqua*

Predictions

- Nearshore upwelling
- Speed and direction of ocean currents
- Ecological Forecasts
- Runoff Change
- Seasonal Forecasts
- Aerosol Properties
- Salinity predictions
- Ocean Surface Currents/ Winds/ Topography
- Sea Surface Salinity/Temperature
- Land Use
- Phytoplankton concentrations

Observations

DECISION SUPPORT TOOLS

HAB (Harmful Algal Bloom) Bulletin & Mapping System

Analysis: Predict landfall, track transport-speed- direction, forecast duration/demise, assess severity

Management: Warning time to fisheries managers, beach closures, shellfish quotas, finfish limits, aquaculture flushing and recirculation, mitigation response

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Coral Reef Early Warning System (CREWS)

Analysis: Assess potential bleaching conditions from wind, temperature, primary productivity

Management: Warning time and automated alerts to managers, mitigation activities

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GNOME - Oil Spill Modeling

Fisheries - Drift Nets

Stormwater Runoff

VALUE & BENEFITS

- Reduce public health risks, hospital admissions, lost work-school days
- Reduce impacts to regional coastal economies & tourism
- Raise quotas for shellfish harvesting prior to HABs; improve siting and design of shellfish beds
- Preserve ecological diversity and tourism economies
- Reduced threats to human and natural environments
- Rapid response to emergencies to reduce effects on human safety and economies
- Public health and reduce preventable costs

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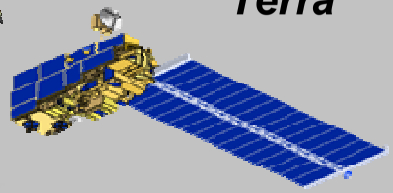
Coastal Management

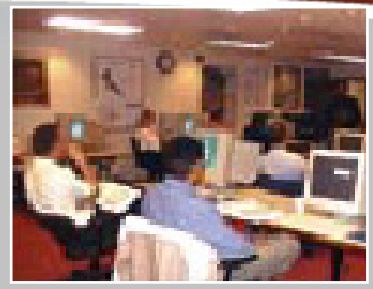
Aqua

SeaWiFs

Terra



Tasking



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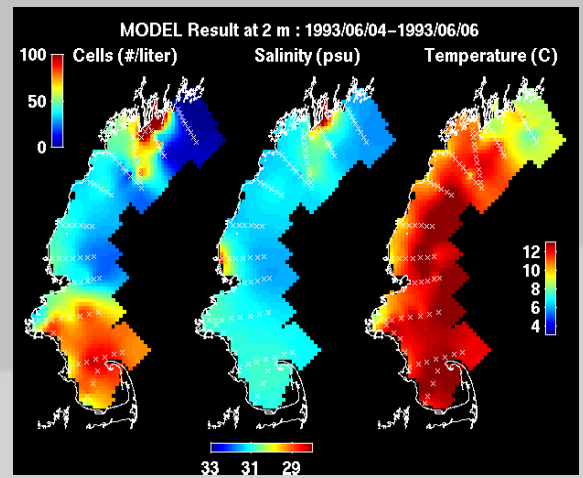
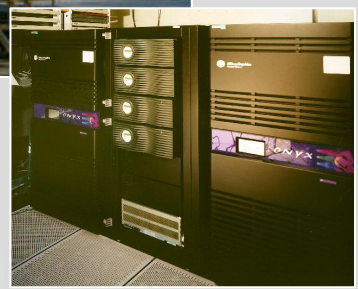


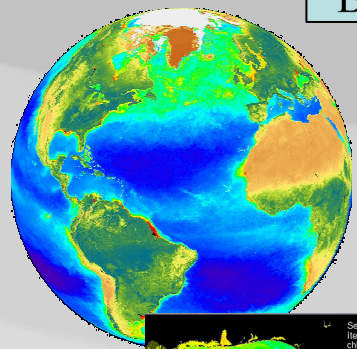
Downlink

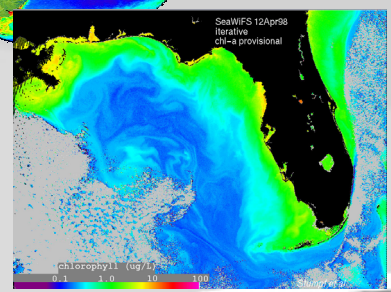
Societal Benefits



EOSDIS & DAACs

Exploitation





Harmful Algal Bloom Bulletin

Carbon Management

Integrated System Solution

EARTH SYSTEM MODELS

Net Ecosystem Production Model:
CASA

- Carbon assimilation in above and below ground biomass,
- Assessment of land and ocean carbon sink strength,
- Soil moisture,
- Land-atmosphere-ocean carbon exchange.

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- **Atmosphere:** *Terra, Aqua, Terrestrial Networks, NPP, NPOESS, OCO*
- **Land:** Terra, *Aura, Landsat,, Terrestrial Networks*
- **Ocean:** SeaWIFS, Aqua, *Terra, NPP, NPOESS*

**Future Mission*

Predictions

Information Products, Predictions, and Data from NASA Applied Sciences Missions and Models:

- Land cover condition and change
- Volume of above ground biomass Forest condition
- Soil moisture
- Agricultural production and yield
- CO_2 concentration in the atmosphere
- Oceanic carbon uptake and storage
- Fire management

Observations

DECISION SUPPORT TOOLS

- Soil carbon sequestration
- Forest management
- Crop planning and rotation
- Irrigation control
- Atmospheric pollution monitoring and prediction
- Energy production (burning of fossil fuels)
- Climate and weather prediction
- Ocean carbon seques-tration

VALUE & BENEFITS

- Climate change mitigation
- Improved efficiency in energy production
- Improved efficiency in crop production through enhancements in soil carbon
- Improved economy in marginal rural agricultural areas
- Climate change mitigation

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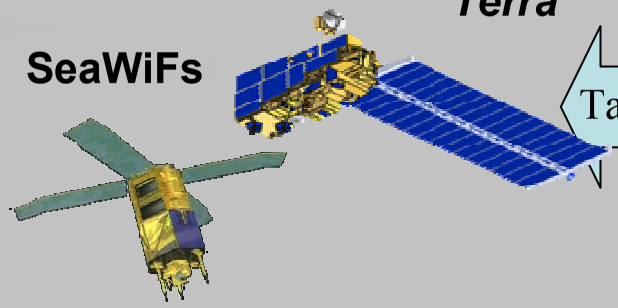
Carbon Management

Terra

SeaWiFs



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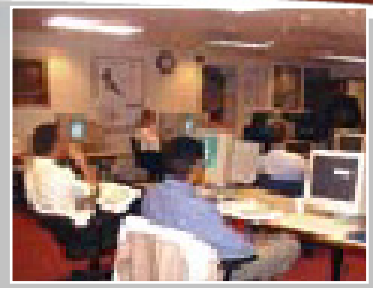
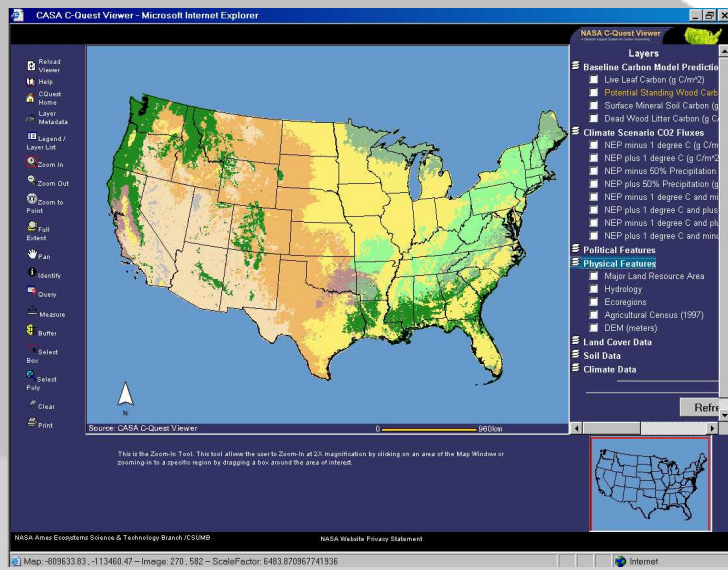


EDOS: Mission Control

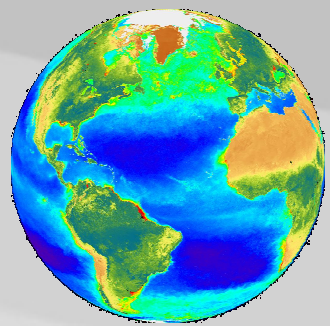
Downlink

Societal Benefits

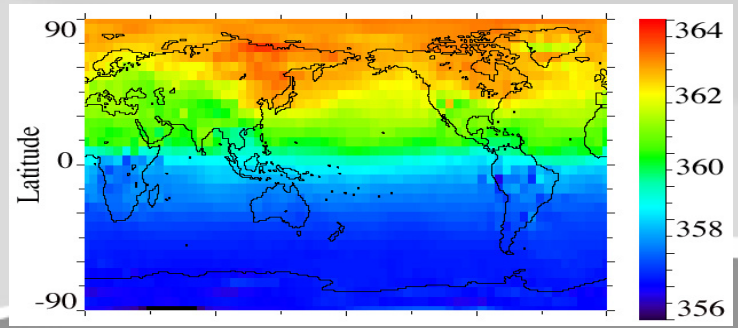


CASA/CQUEST

Exploitation



EOSDIS & DAACs



January 25, 2005

Disaster Management

Integrated System Solutions

EARTH SYSTEM MODELS

- **Weather:** *FVGCM, ETA-12, WRF*
- ***Hurricane:*** *HURSIM, H*Wind, HUREVAC*
- ***Earthquake/Landslide:*** *MMI, QuakeSim, GPS*
- ***Flood:*** *SLOSH, FLDWAVE, SBEACH, WAVEWATCH III, STWAVE, HURSURGE*
- **Damage Cost Models:** *ATC-13*
- **Wildfire:** *FARSITE, BEHAVE*
- **Terrain:** *BARC*

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- **Land Surface Topography/Land Use/Cover:** LandSat *SRTM, ASTER, TERRA/AQUA, AVHRR,* ***AURA***
- **Wind/Weather:** *QuickSCAT, GOES,* ***AURA, NPP, NPOESS, GOES-R***
- **Ocean Surface Height/Waves:** Topex-Poseidon
- **Global/Regional Precipitation:** TRMM, AVHRR, GOES, DMSP, **GPM**

**Future Mission*

Predictions

- Hazard Maps
- Earthquake vulnerability and prediction
- Flooding and coastal inundation
- Hurricane/Typhoon Track and Intensity
- Precipitation amount
- Wind Velocity/Direction
- Surface Deformation

Observations

- Atmospheric Temperature Water Vapor, Winds
- Severe Weather (Lightning)
- Volcanic Ash
- Aerosols, Smoke
- Cloud Properties
- Global Precipitation
- Land/Terrain/Use/Veg
- Aquifers
- Wetlands

DECISION SUPPORT TOOLS

NOAA/AWIPS (**A**utomated **W**eather **I**nformation **P**rocessing **S**ystem)

- Weather prediction and observations
- Weather watches and warnings
- Data Dissemination Assimilation, models
- Public Access to information

DHS/FEMA HAZUS-MH – Hazards U. S.

- Disaster Mitigation/ Preparedness
- Built Environment risk & loss
- Socio-economic impacts

USDA/Forest Service: RSAC - Remote Sensing Applications Center

- Wildfire location/intensity
- Post Fire Recovery
- Strategic/Tactical Operations

VALUE & BENEFITS

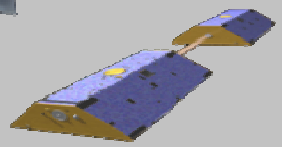
- Identify/Prioritize high-risk communities
- Reduction in lives and property lost
- Reduction in damage cost and time to recovery
- Anticipate the scope of disaster-related damage
- Improve disaster response
- Community Planning
- Land Resource preservation

January 25, 2005

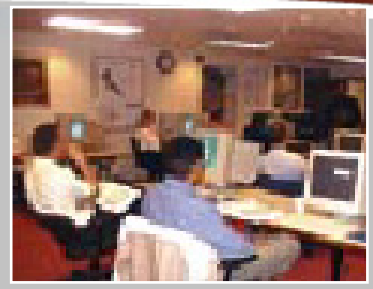
Disaster Management

QuikScat

GRACE



Tasking

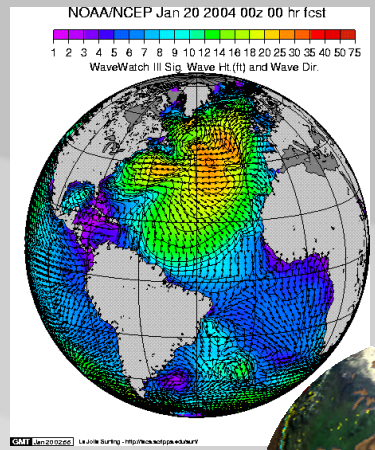


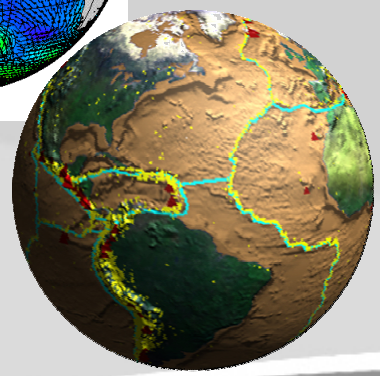
EDOS: Mission Control

Downlink

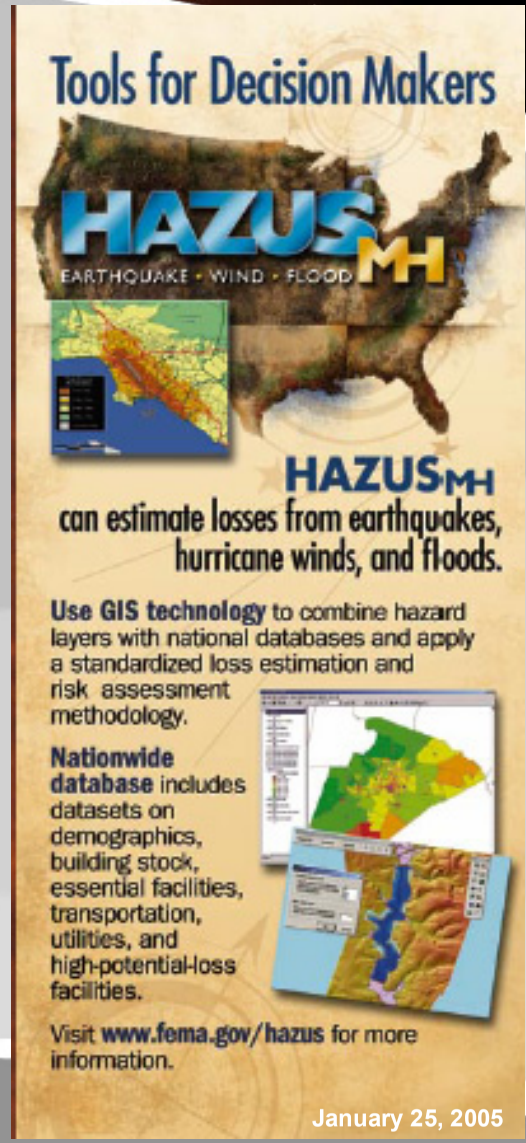
EOSDIS & DAACs

Exploitation





Societal Benefits



Ecological Forecasting

Integrated System Solution

EARTH SYSTEM MODELS

- Ecological Niche (GARP)
- Scalable spatio-temporal models a la CSU's NREL
- Regional Ocean Models & Empirical Atmospheric Models coupled with ecosystem trophic models
- Ecosystem (ED, CASA)
- Population & Habitat Viability Assessment (VORTEX, RAMAS GIS)
- Biogeography (MAPSS, BIOME3, DOLY)
- Biogeochemistry (BIOME-BGC, CENTURY, TEM)

**Supported Non-NASA Model*

Predictions

- Species Distributions
- Ecosystem Fluxes
- Ecosystem Productivity
- Population Ecology
- Land Cover Change

Data

EARTH OBSERVATORIES

- **Land cover**: MODIS, AVHRR, Landsat, ASTER, ALI, Hyperion, IKONOS/QuickBird
- **Topography/Vegetation Structure**: SRTM, ASTER, IKONOS, LVIS, SLICER, Radars
- **Primary Productivity/Phenology**: AVHRR, SeaWiFS, MODIS, Landsat, ASTER, ALI, Hyperion, IKONOS, QuickBird, AVIRIS
- **Atmosphere/Climate**: AIRS/AMSU/HSB, TRMM (PR, LIS, TMI), AVHRR, MODIS, MISR, CERES, QuikScat
- **Ocean**: AVHRR, SeaWiFS, MODIS, TOPEX/Poseidon, JASON, **AQUARIUS**
- **Soils**: AMSR-E, AIRSAR

**Future Mission*

- Land Cover/Land Use & Disturbances (e.g., fire)
- Species Composition
- Biomass/Productivity
- Phenology
- Vegetation Structure
- Elevation
- Surface Temperature
- SST, SSH, Circulation, & Salinity
- Atmospheric Temp.
- Soil Moisture
- Precipitation
- Winds

Observations

DECISION SUPPORT TOOLS

SERVIR (Spanish acronym for Regional Visualization & Monitoring System)

- Monitor changes in land cover, weather, & fires to assist the sustainable management of the Mesoamerican Biological Corridor

Protected Area Management with ALDO & TOPS

- Coordinate multi-NGO effort to pool resources for monitoring protected areas
- Link to President's logging initiative & CBFP

Impact of ENSO & PDO Events on Fisheries

- Combine physical ocean & ecosystem trophic-level models to predict how climatological changes driven by ENSO & PDO events will affect regional fisheries

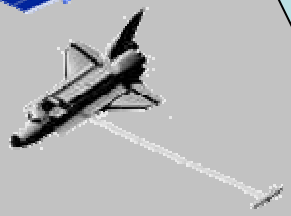
VALUE & BENEFITS

- Management of a global hotspot of biodiversity, i.e. Mesoamerica, at a regional scale through the coordination of the activities of 7 countries - a model for other regions.
- Predict the impacts of changing land use patterns & climate on the ecosystem services that support all human enterprises.
- Develop ecological forecasts with reliable assessments of error.

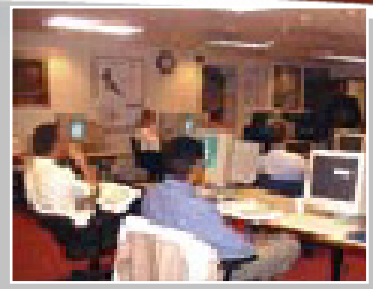
Ecological Forecasting

Terra

SRTM



Tasking

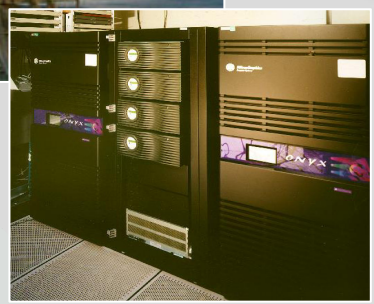


EDOS: Mission Control

Downlink

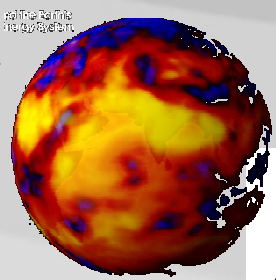
Societal Benefits

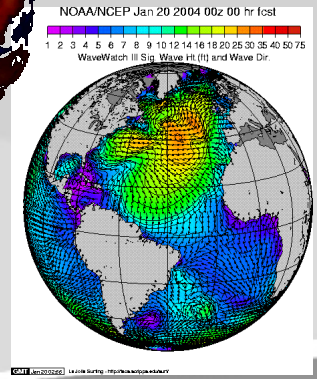
SIAM-SERVIR Center in Panama City



EOSDIS & DAACs

Exploitation





Energy Management

Integrated System Solution

EARTH SYSTEM MODELS

- Earth System & Climate Change: *GMAO Analysis, NCEP Analysis*
- Seasonal Prediction Models: *NSIPP Analysis, NCEP Analysis*
- Aerosol Transport Models: *RAQMS, DAO fvCAM, NCAR WRF, GFDL FMS Atmosphere*
- Climate Models: *GISS Model II, GFDL FMS B-Grid Atmosphere*
- Atmospheric Analysis Models/Datasets: *ISCCP, SRB, CERES-SARB, GVAP, GPCP*

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- **Atmosphere:** *GOES, POES, TRMM, Terra, Aqua, TOMS, Aeronet, AIRNow, **INTEX, Aura, Calipso Glory, CloudSat, GPM, NPP, GIFTS, HYDROS***
- **Land :** *Terra, Aqua, Landsat, Terrestrial Networks, BSRN, ARM, SURFRAD*

**Future Mission*

Predictions

- 20+ years
- Past 90 days
- 1 – 15 day forecasts
- 12 – 18 month seasonal forecasts
- 10 – 20 year forecasts

- Temperature & humidity profiles
- Cloud systems
- Land cover albedo
- Land surface temperature
- Soil Moisture
- Ocean Surface Winds
- Global Precipitation
- Total Aerosol Amount
- Land Surface Topography
- Trace gas profiles

Observations

DECISION SUPPORT TOOLS

NREL

- National Solar Radiation Database
- Provides data sets for numerous energy management decisions

EPRI

- Neural Net Load Forecast Tools
- Forecasting tool for Energy industry
- Integration of renewable sources to traditional power grids

RETScreen

- Provides common platform for evaluating project proposals while significantly reducing the costs and uncertainties of preliminary studies
- Reduces the time and errors of a preliminary study

VALUE & BENEFITS

- Optimize renewable energy systems for power production
- Optimal integration of traditional and renewable energy supply systems into electric power grid
- Improved prediction of electric power need and supply – mitigate power shortages, prevent price increase
- Reduction in greenhouse emissions from energy production

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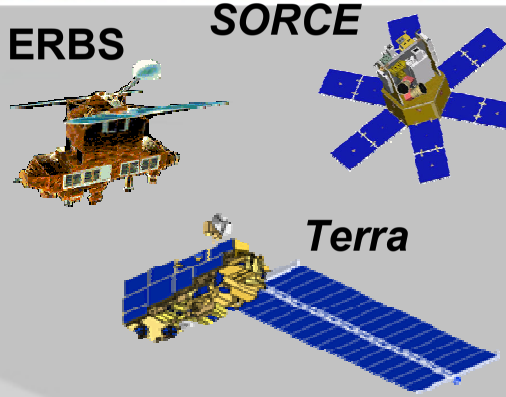
Energy Management

ERBS

SORCE

Terra



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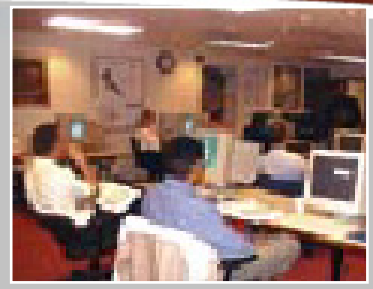
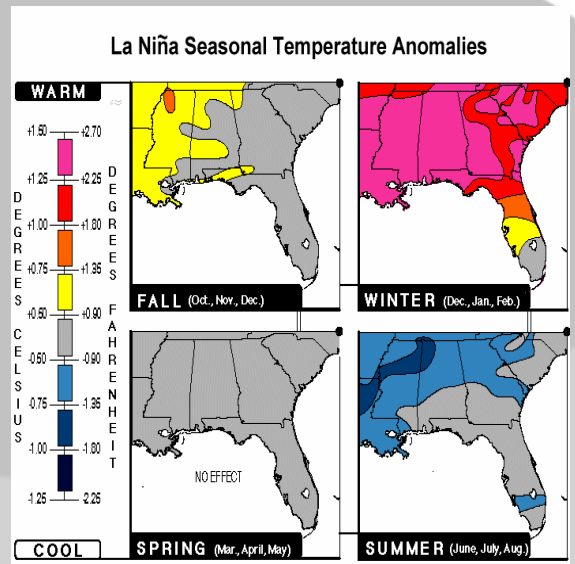


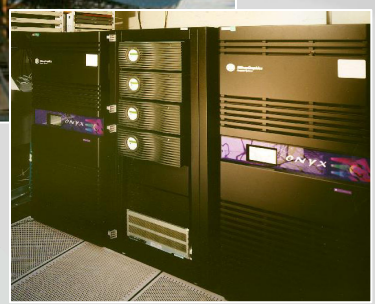
EDOS: Mission Control

Downlink

Societal Benefits

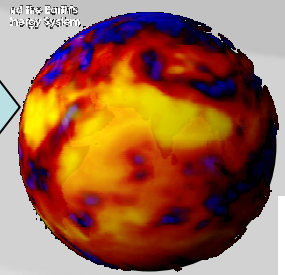


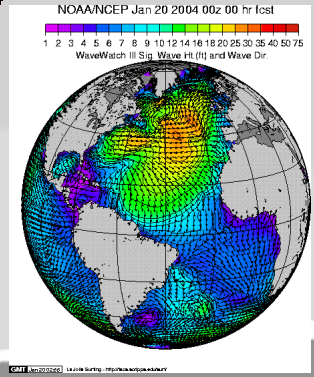
National Energy Management System



EOSDIS & DAACs

Exploitation





Homeland Security

Integrated System Solution

EARTH SYSTEM MODELS

- Air Plume/deposition Models: *ALOHA, HYSPLIT*
- Hydrologic and Hydraulic Models: *FLDWAVE*
- Weather: *ETA, Aviation (NCEP)*
- Agriculture/Biology: *Vegetation NDVI, Vector Models*

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- **Land:** *Landsat, SRTM,* GPS-SCIGN, Terra, Aqua, GRACE
- **Ocean:** *QuickSCAT, Seawinds, IceSAT, GOES, POES, SSMI, JASON, TOPEX/POSEIDON*
- **Atmosphere:** *TRMM, GOES, POES, GPM, NPP, NPOESS*

**Future Mission*

Predictions

- Nuclear, Chemical, Biological, & Radiological Concentrations
- Precipitation Distribution
- Wind Velocity/ Direction
- Surface Topography

Observations

DECISION SUPPORT TOOLS

IOF – Integrated **O**perations **F**acility

- Integrated Operations and Coordinated Response
- Disaster Recovery/ Mitigation
- Loss estimates of buildings, essential facilities, transportation & utility lifelines, and population
- Social impacts

VALUE & BENEFITS

- Identify/ Prioritize high-risk communities
- Reduction in lives lost
- Reduction in damage cost and time to recovery
- Anticipate the scope of disaster-related damage
- Improve disaster response

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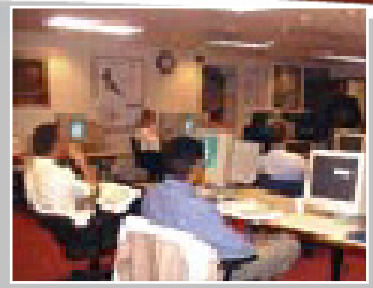
Homeland Security

Aura

QuikScat

Tasking



EDOS: Mission Control

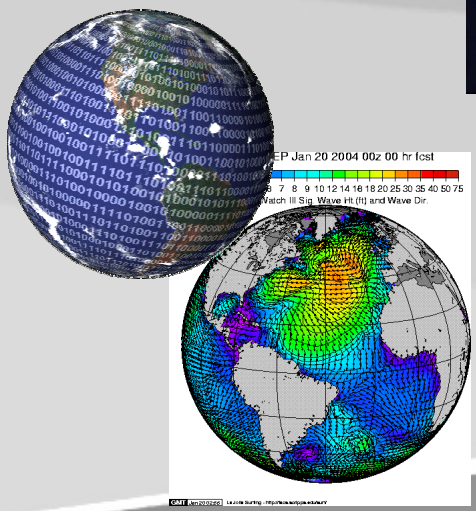
Downlink

Societal Benefits

Interagency Modeling Atmosphere Assessment Center (IMAAC)

Exploitation

EOSDIS & DAACs



Invasive Species

Integrated System Solution

EARTH SYSTEM MODELS

- Climate models and impact on vegetation distribution
- Vegetation structure
- Land cover change
- Biodiversity and ecosystem models
- Impact of anthropomorphic events
- Trend Surface Analysis: ***OLS,GLS,SAR***

Supported Non-NASA Model

Data

EARTH OBSERVATORIES

- Terra
- Aqua
- TRMM
- Landsat 7 (LDCM
- EO-1
- OCO
- Aquarius
- HYDROS
- GPM
- NPP/VIIRS
- (VCL)
- NPOESS

Predictions

- Information Products, Predictions, and Data from NASA Applied Sciences Missions and Models:

- Land cover and land cover change
- Climate and weather
- Location and condition of invasive species
- Soil moisture
- Water quality and recreation

Observations

DECISION SUPPORT TOOLS

ISFS (Invasive Species Forecasting System)

- **Invasive species forecasting system**
- **Livestock grazing control**
- **Water quality and Availability**
- **Fishing management**
- **Recreation and tourism**
- **Public health**

VALUE & BENEFITS

- Reduced cost for invasive species control
- Improved water quality
- Reduced risk of disease to humans and livestock
- Improved recreation
- Improved freshwater fishing
- Reduced costs for boating and waterway maintenance

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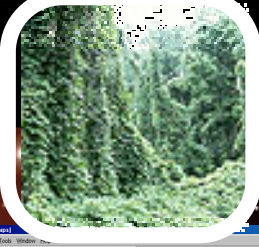
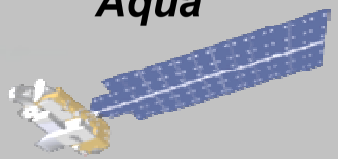
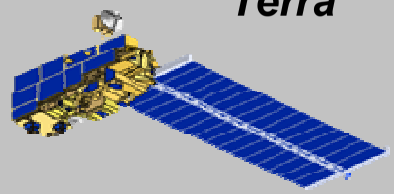
Invasive Species



Aqua



Terra



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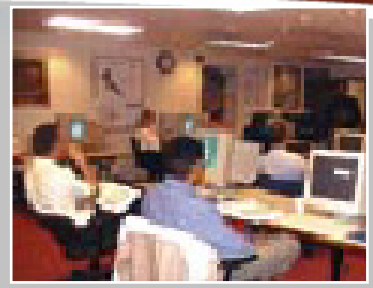
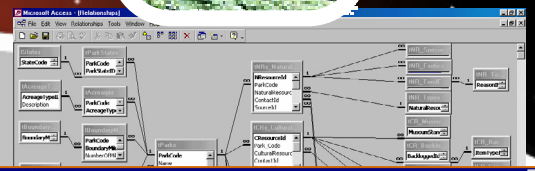
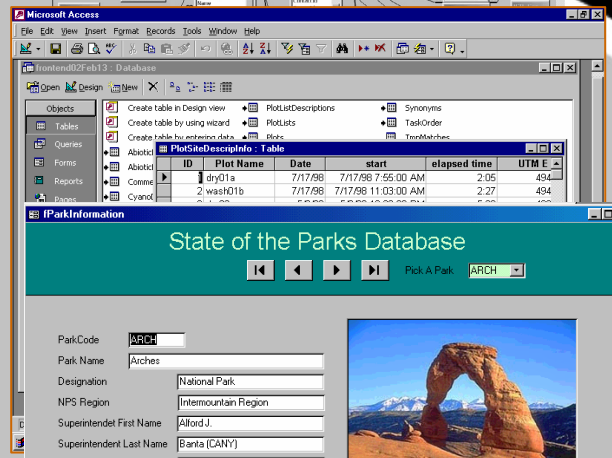


EDOS: Mission Control

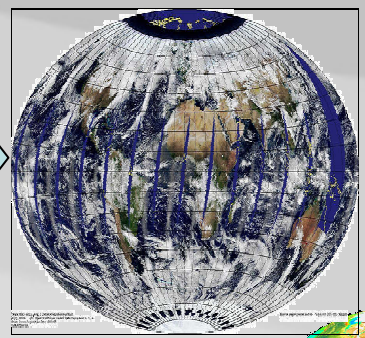




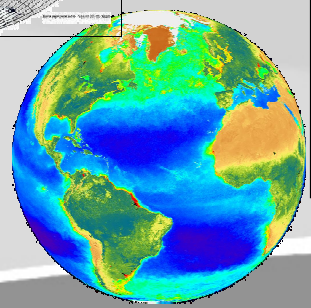
Downlink

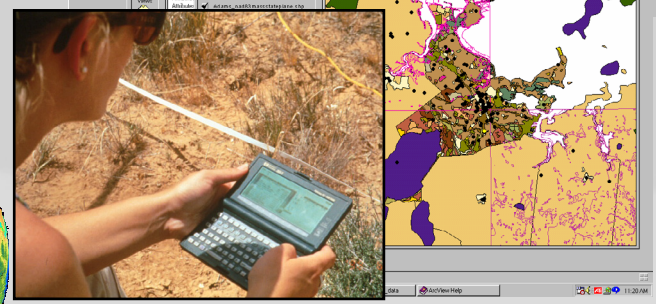
Societal Benefits

Exploitation



EOSDIS & DAACs





Invasive Species Forecasting System

January 25, 2005

Public Health

Integrated System Solution

EARTH SYSTEM MODELS

Terrestrial / Atmospheric: *MAESTRO**

Climate Variability Models: *GHCN*

Land Surface Model: *CLSM, LSE*

Weather/ Seasonal Models: *COLA*

Science & Research: *GSFC Plague Algorithm*

Atmospheric / Ocean Models: *GMAO*

Data

EARTH OBSERVATORIES

- EO-1
- TRMM
- Terra, Aqua
  - ASTER
  - MISR
  - MODIS
- Landsat 4, 5, 7
- NPOESS*
- SRTM

- Land cover / land use
- Surface temperature
- Vegetation indices
- Aerosol properties
- Surface topography

*Future Mission

Predictions

- Soil Moisture
- Atmosphere Temp
- Ground Temp
- Humidity
- Precipitation
- Total Column Ozone
- Total Aerosol Amount

Observations

DECISION SUPPORT TOOLS

- **PSS**
  - Image output maps for PSS monitoring & scientific analysis
  - Technologies for verification & validation of satellite data to serve PSS
- **EPHTN / HELIX**
  - Technologies for verification & validation of satellite data to serve EPHTN
  - Data pipelines for direct feed of environmental measurement data to EPHTN-networked systems
  - New or improved disease models
  - Image output maps for EPHTN monitoring and scientific analysis
- **Malaria Surveillance**
  - Vector Habitat Identification
  - Identify Key Factors that Sustain or Intensify
  - Transmission
  - Risk Prediction
- **Rapid Syndrome Validation Project**
  - Improve knowledge of vector ecology
  - Improve NCEP-ETA model w/ DREAM inputs
  - Improve DREAM inputs w/ NASA products
  - Improve aerosol & smoke dispersion models w/ NASA products

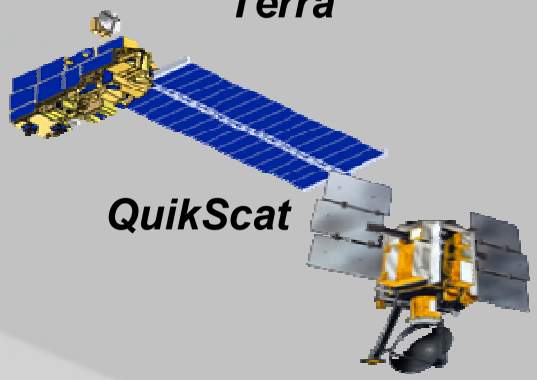
VALUE & BENEFITS

- **Early Warnings for harmful exposures, conditions favorable to vector proliferation.**
- **Reduction of environmental-related diseases.**
- **Improved prevention initiative targeting.**

January 25, 2005

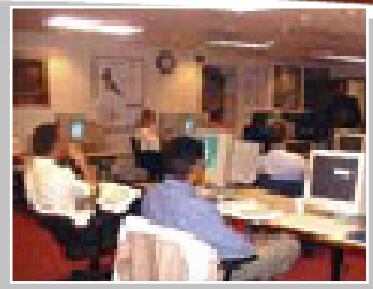
Public Health

Terra



QuikScat

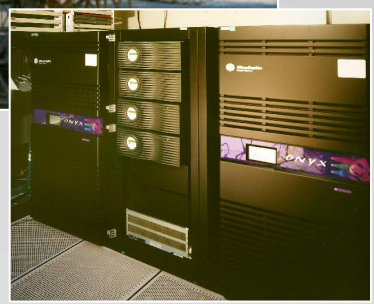
Tasking



EDOS: Mission Control

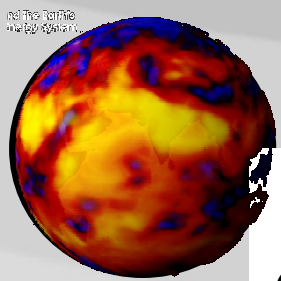
Downlink

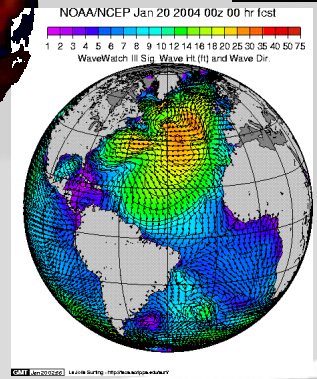
Societal Benefits



EOSDIS & DAACs

Exploitation





Environmental
Public Health
Tracking Network

Water Management

Integrated System Solution

EARTH SYSTEM MODELS

- **Mesoscale Models:** *MM5, CSU RAMS*
- **General Circulation models**: *GMAO (DAO & NSIPP), NCEP ETA*
- **LSMs:** *MOSAIC, Noah, VIC, Catchment, CLM2, SWAT*
- **In Stream Water Quality Model:** *QUAL2E*
- **Non-Point source annual loading model:** *PLOAD*
- **Watershed loading and transport models**: *HSPF*

**Supported Non-NASA Model*

Data

EARTH OBSERVATORIES

- Surface Temperature: *Terra, Aqua, GOES*
- Precipitation: *TRMM, Aqua, GOES*
- Soil Moisture: *Aqua, TRMM, NPOES*
- Snow Cover: *Aqua, Terra*
- Snow Quantity: *Aqua*
- Groundwater Change: *Grace*
- Land Use/Cover: *Terra, Aqua, Landsat*
- Surface Radiation: *GOES, Terra, Aqua, Aster*

Predictions

- Soil Moisture
- Evapotranspiration
- Precipitation
- Snow cover, accumulation, and water equivalent:
- Groundwater storage change
- Vegetation type
- River discharge height
- Flood and Drought Assessment and Prediction
- Seasonal Forecasts

Observations

DECISION SUPPORT TOOLS

- **BASINS** (**B**etter **A**ssessment **S**cience **I**ntegrating Point and **N**on-point **S**ources
  - Facilitate examination of environmental information
  - Provides an integrated watershed and modeling framework
  - Support analysis of point and non-point source management alternatives
  - Urban/Rural land use evaluations
- **AWARDS** (**A**gricultural **W**ater **R**esources **D**ecision **S**upport)
  - Estimates of water consumption by crops
  - Crop suitability assessment
  - Irrigation requirements
- **RiverWare**
  - Estimates of river flow and water loss to vegetation
  - River sustainability assessment

VALUE & BENEFITS

- Improvements in identifying:
  - ❖ impaired surface waters
  - ❖ storm water management issues
  - ❖ drinking water source protection
- Improvement in habitat management practices
- Improved efficiency of water use
- Increased Agricultural productivity

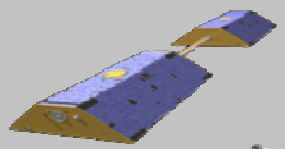
January 25, 2005

Water Management

Bureau of Reclamation
Managing Water In The American

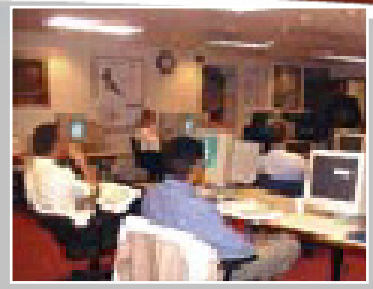
USGS
science for a changing world

GRACE



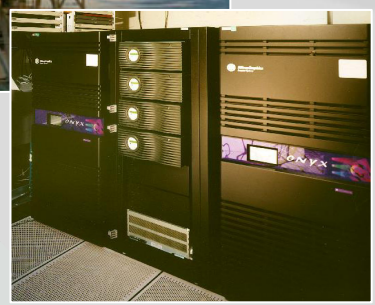
Terra

Tasking



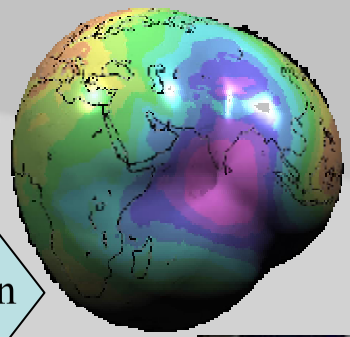
EDOS: Mission Control

Processing

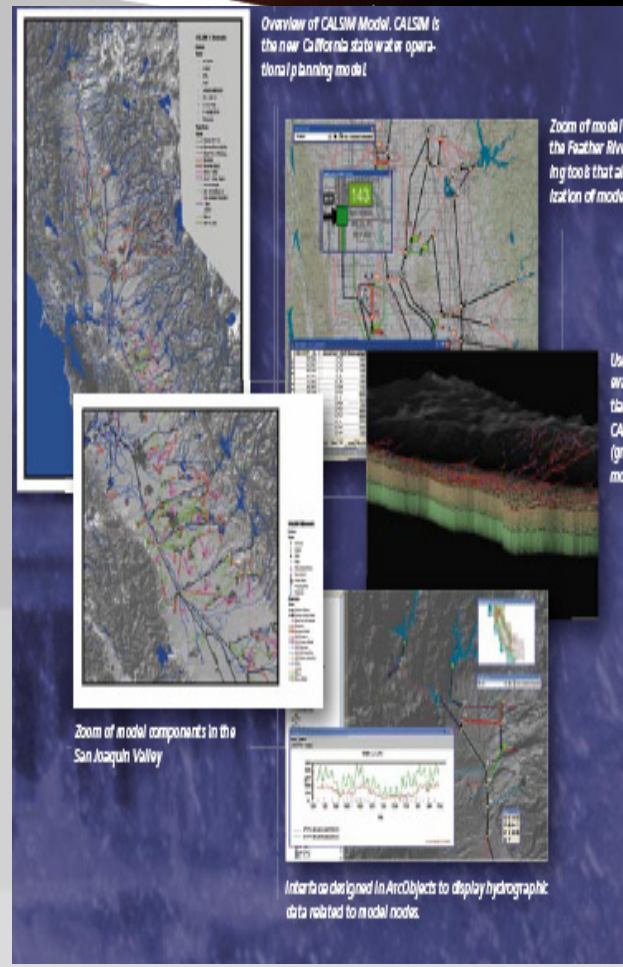


EOSDIS & DAACs

Exploitation



Societal Benefits



Riverware
& AWARDS

From Observations to Knowledge Products

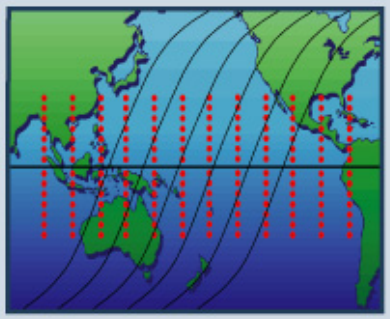
"from photons to electrons to neurons"

Downlink Speed

Petabytes 10^{15}

Multi-platform, multiparameter, high spatial and temporal resolution, remote & in-situ sensing

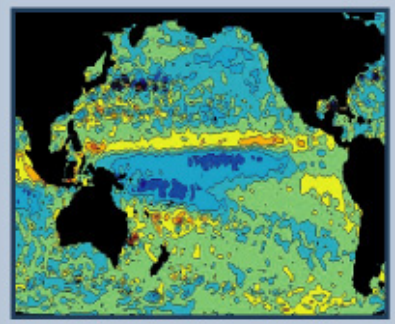
Advanced Sensors



Terabytes 10^{12}

Calibration, Transformation To Characterized Geo-physical Parameters

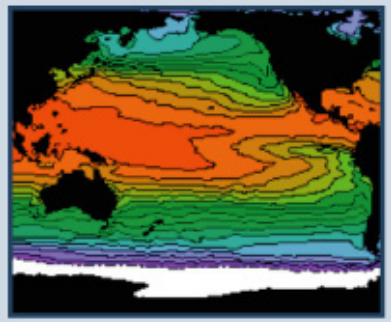
Data Processing & Analysis



Gigabytes 10^{9}

Interaction Between Modeling/Forecasting and Observation Systems

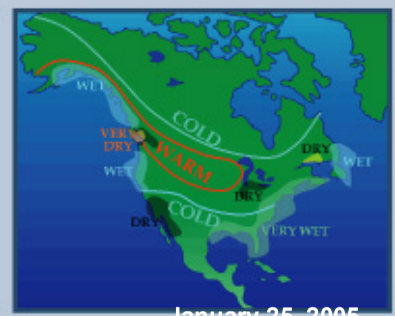
Information Synthesis



Megabytes 10^{6}

Interactive Dissemination and Predictions

Access to Knowledge



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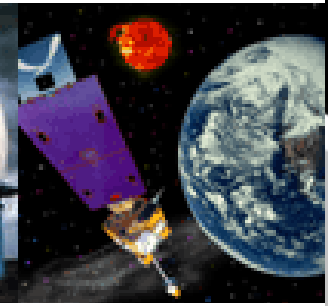
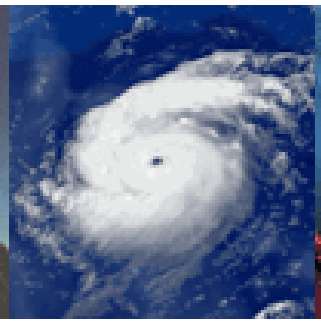
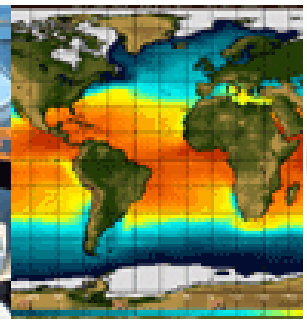
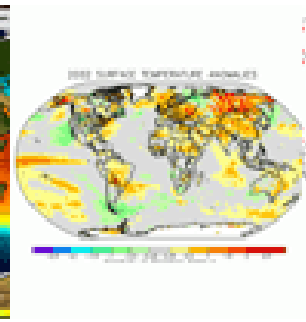
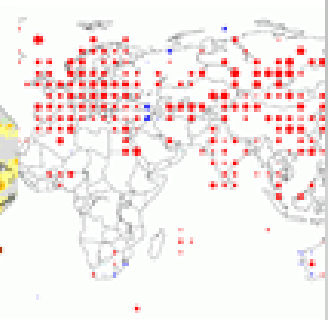
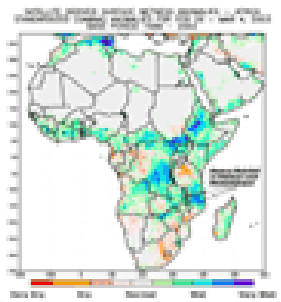
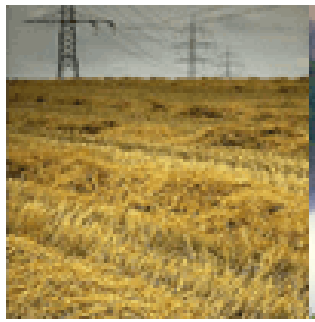
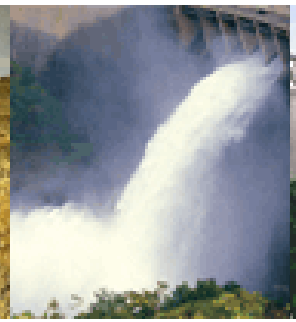
Global Earth Observations for Society

Global Earth Observing System of Systems



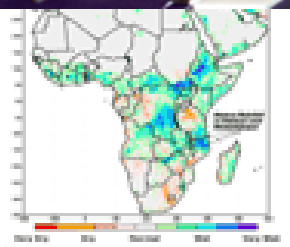


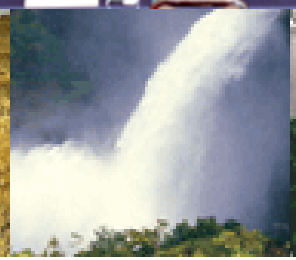







From Observations to Users to Benefits

Global Earth Observations for Society

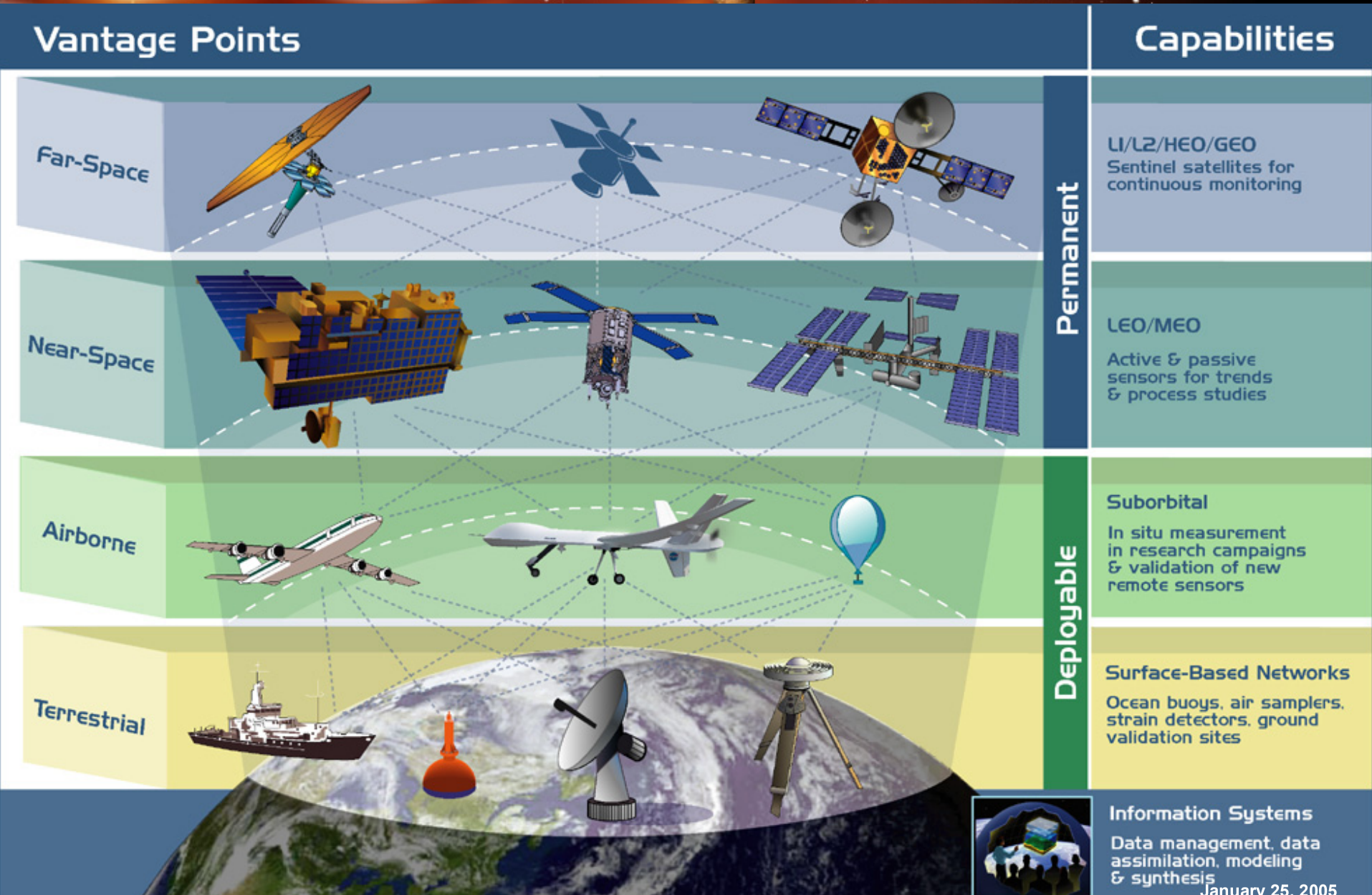
Global





From Observations to Users to Benefits

Global System for Earth Observation Integrating Orbital, Suborbital and In Situ Components

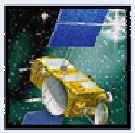


January 25, 2005

Next Generation Missions

NPOESS Preparatory Project

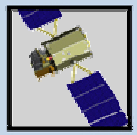
Landsat Data Continuity Mission Instruments



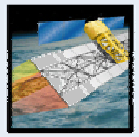
Ocean Surface Topography Mission

Ocean Vector Winds Mission

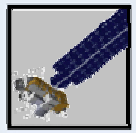
Global Precipitation Measurement



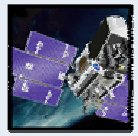
Aerosol Polarimeter Sensor Instruments



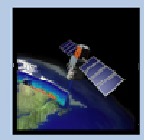
Synthetic Aperture Radar



Chemistry/Climate Mission



Cryosphere Monitoring Mission



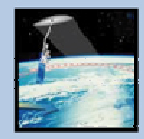
Calipso

Cloudsat

Next generation systematic measurement missions to extend/enhance the record of science-quality global change data

Orbiting Carbon Observatory

Aquarius



Hydros

Research missions to probe key Earth system processes globally for the first time

Blue Horizons

Restless Planet

Aiolos

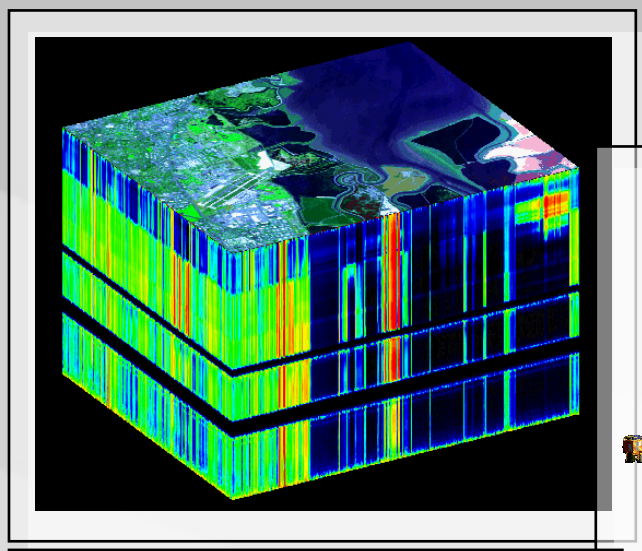
• • •

Candidate Future Missions
In Formulation/Preformulation or in Development

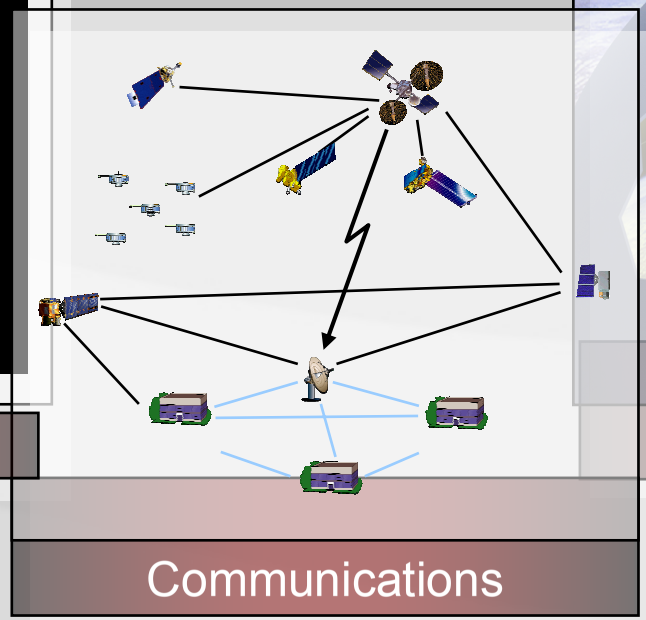
Future research Measurements

Technologies for Exploration

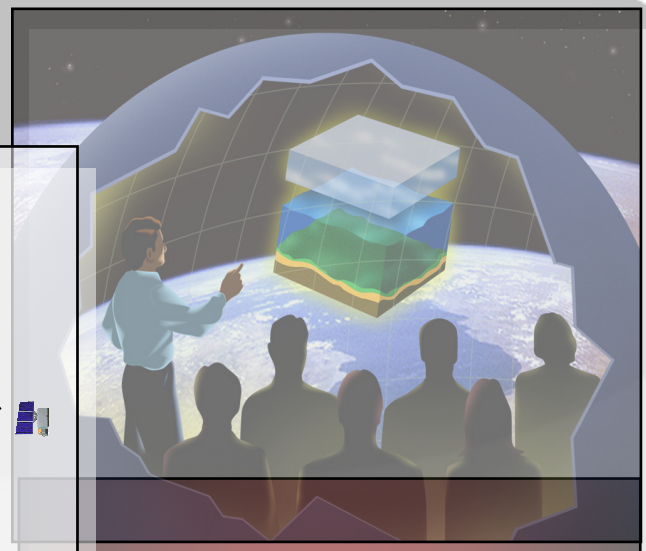
Connecting Geospatial, Communications and Computing Infrastructure



Remote Sensing



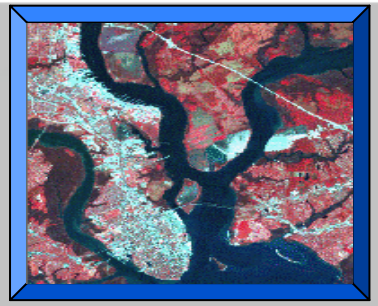
Communications



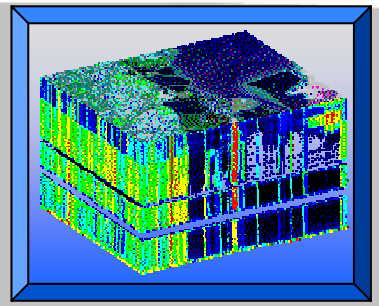
Computing

...to enable timely and affordable delivery of Earth Science data and information

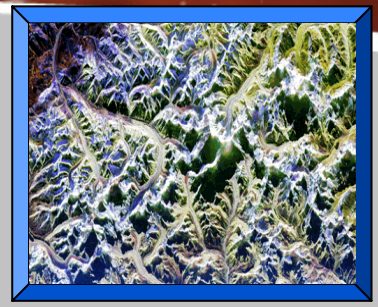
Remote Sensing Technologies



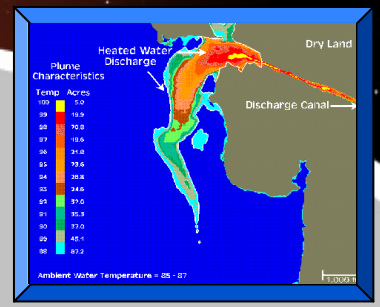
Multispectral



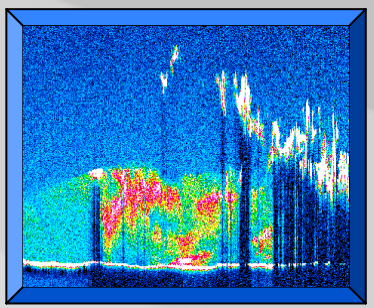
Hyperspectral



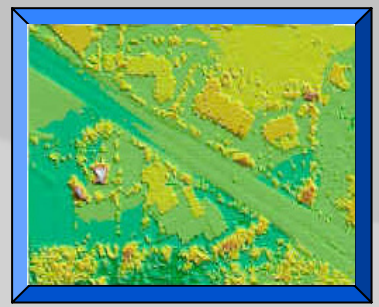
RADAR / SAR



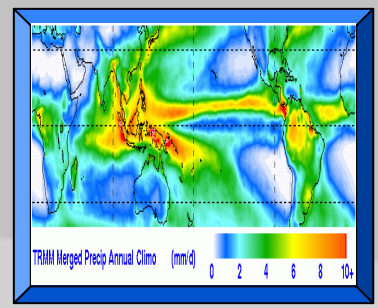
Thermal



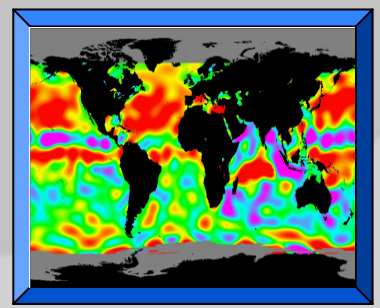
Atmospheric LIDAR



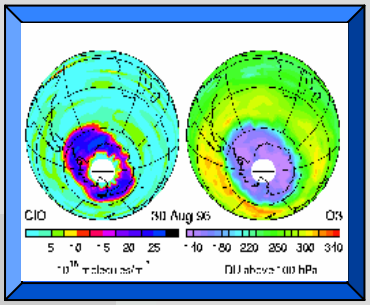
Surface LIDAR



Passive Microwave

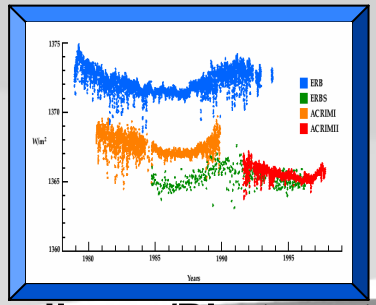


RADAR Altimetry

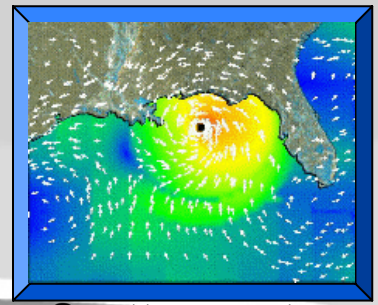


Limb Sounding

Microwave Ranging



Irradiance/Photometry

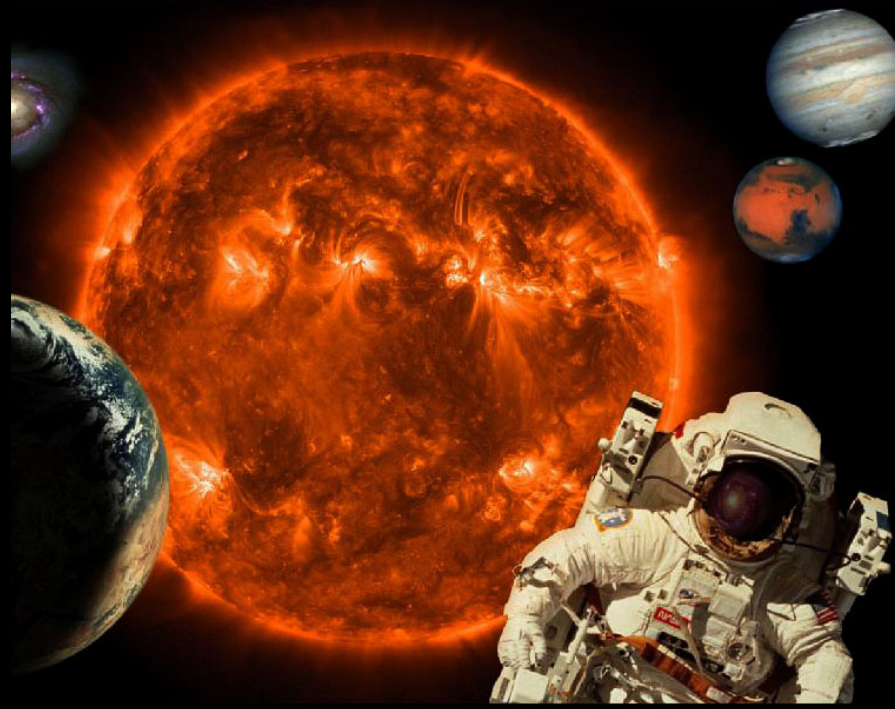


Scatterometry

Inspiring the Next Generation of Earth Explorers

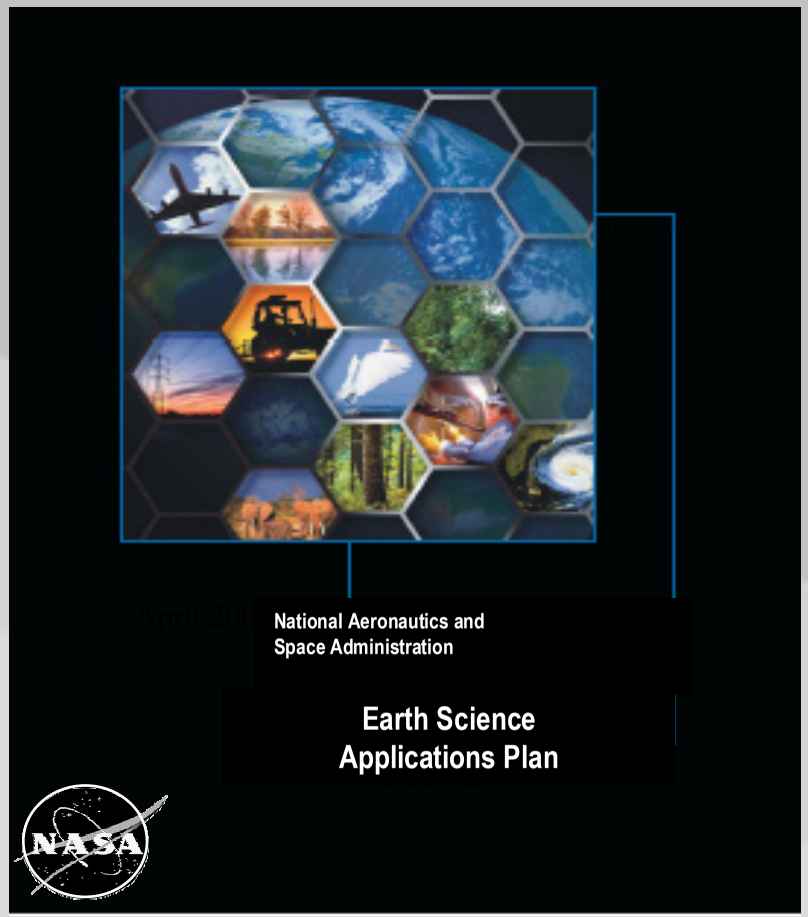
Challenges Ahead

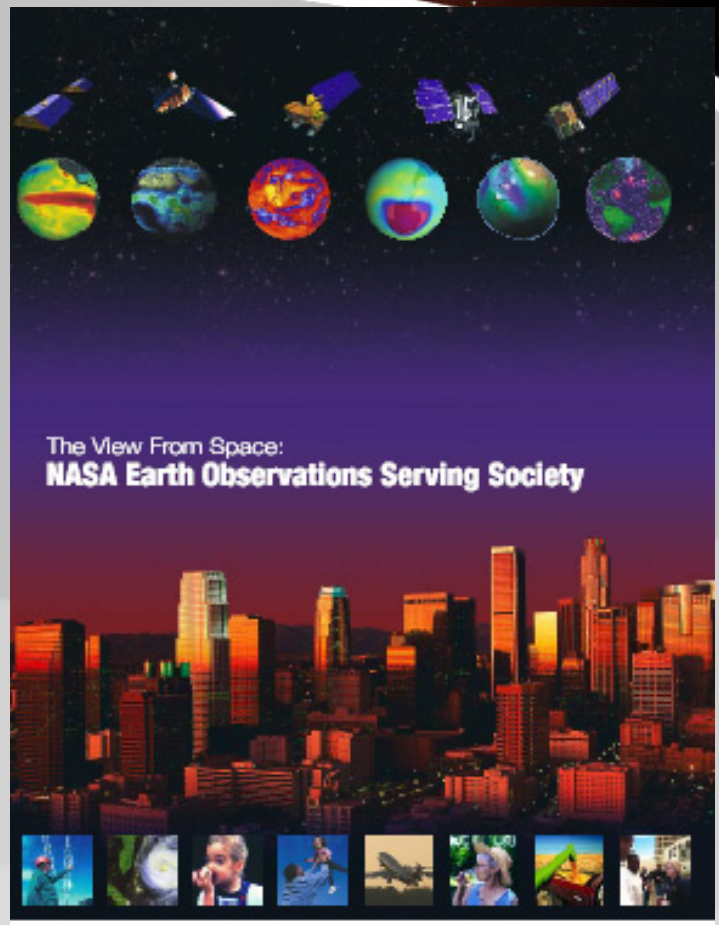
- Characterizing, understanding & predicting the interactions among the Sun, the Earth, and its continents, oceans, atmosphere, ice, and life
- Evolution of a comprehensive, coordinated and sustained Earth observation system
- Forging the partnerships required to sustain the system and its uses for scientific exploration and practical applications
- Applying the knowledge, capacity and systems from Earth-Sun System Science to Exploration
- Training the next generation of scientists, engineers, and decision-makers



January 25, 2005

NASA Science for Society



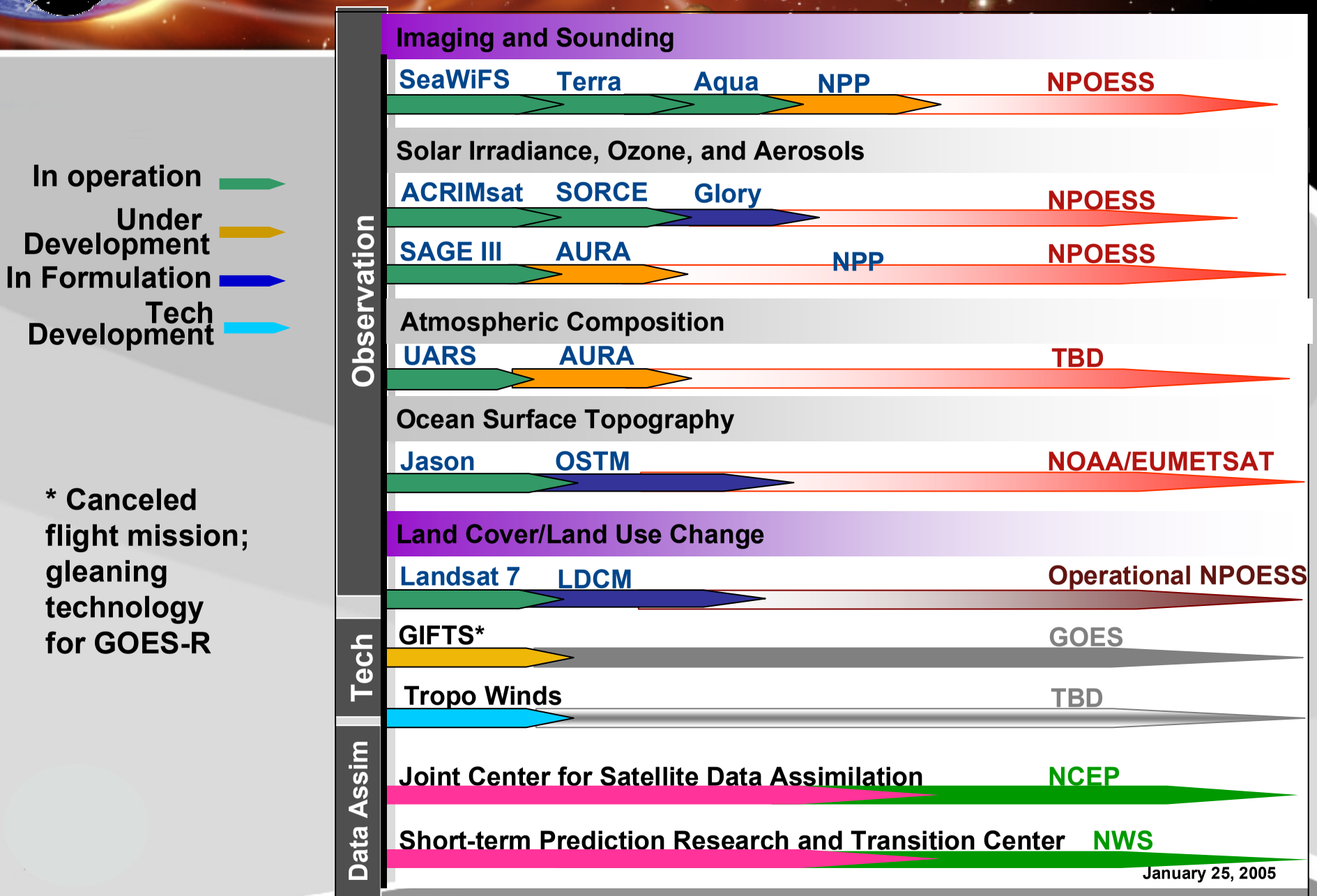


www.earth.nasa.gov/eseapps

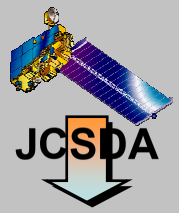
Challenges and Risks

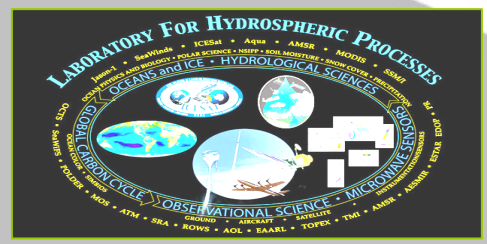
- Transitioning from research to operations
- Characterizing uncertainty in model forecasts for weather, climate, and natural hazards
- Computing capacity to handle volume and range of data from NASA Earth observatories
- Transferring observations and model outputs to nodes throughout the Grid and network of laboratories and universities
- Establishing an Earth Science Gateway portal to provide interoperability and access between scientists and decision makers

Research Results to Operations



Characterizing Uncertainty:
Earth-Sun System Laboratories



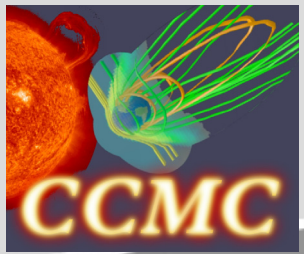


SPoRT

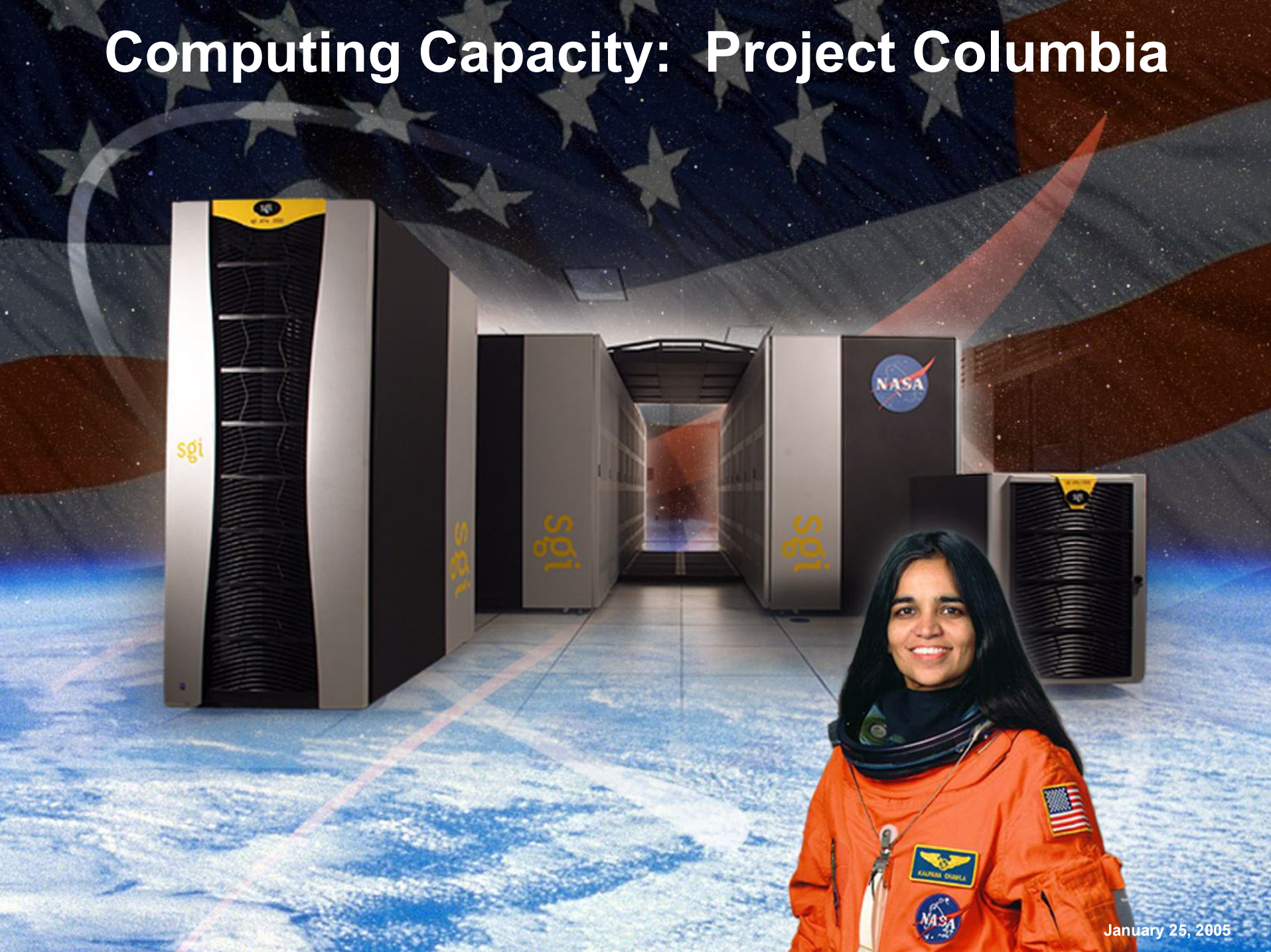
NASA Goddard Space Flight Center
LABORATORY FOR ATMOSPHERES

National Centers for Environmental Prediction

Office of Research and Applications

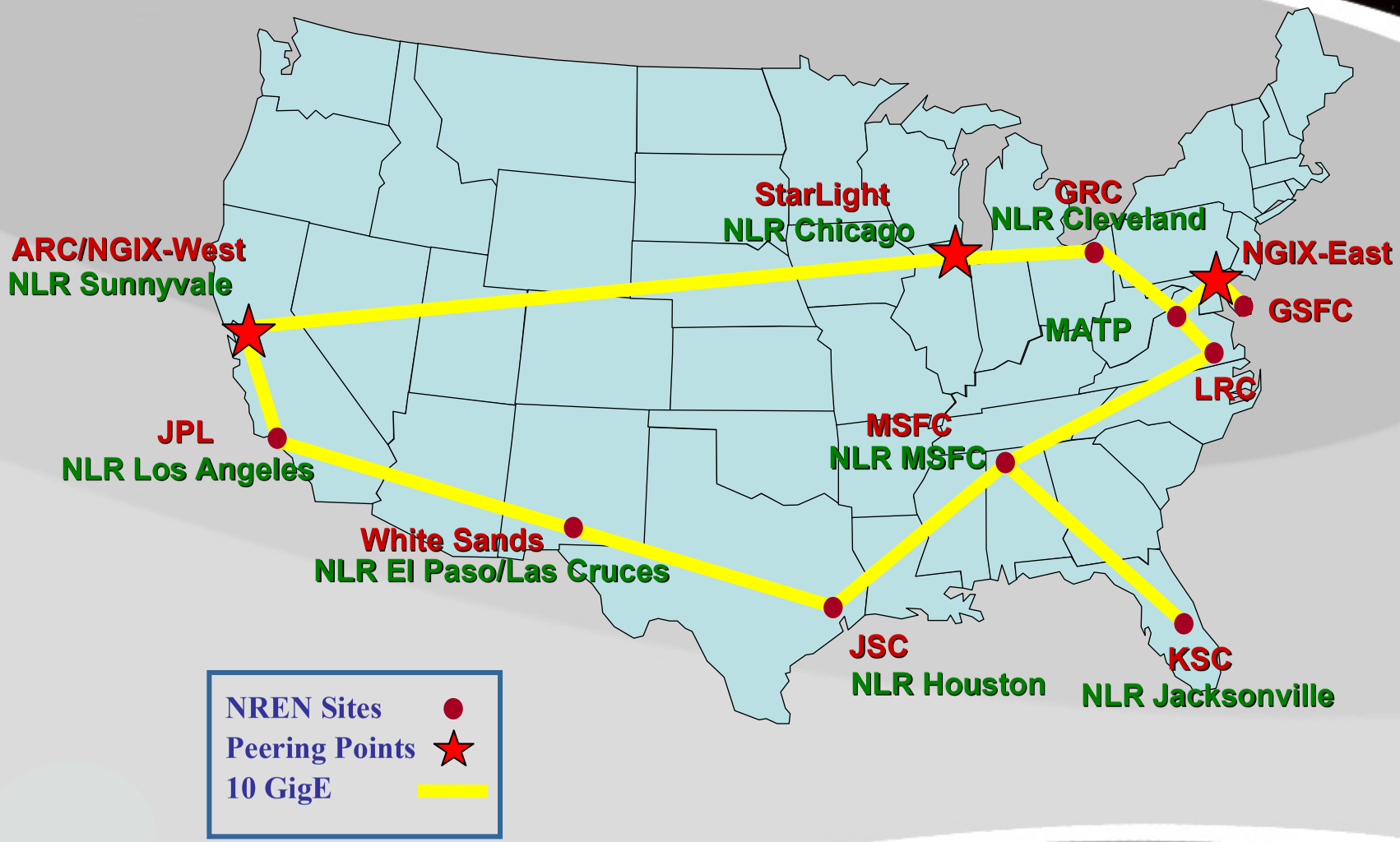


Computing Capacity: Project Columbia

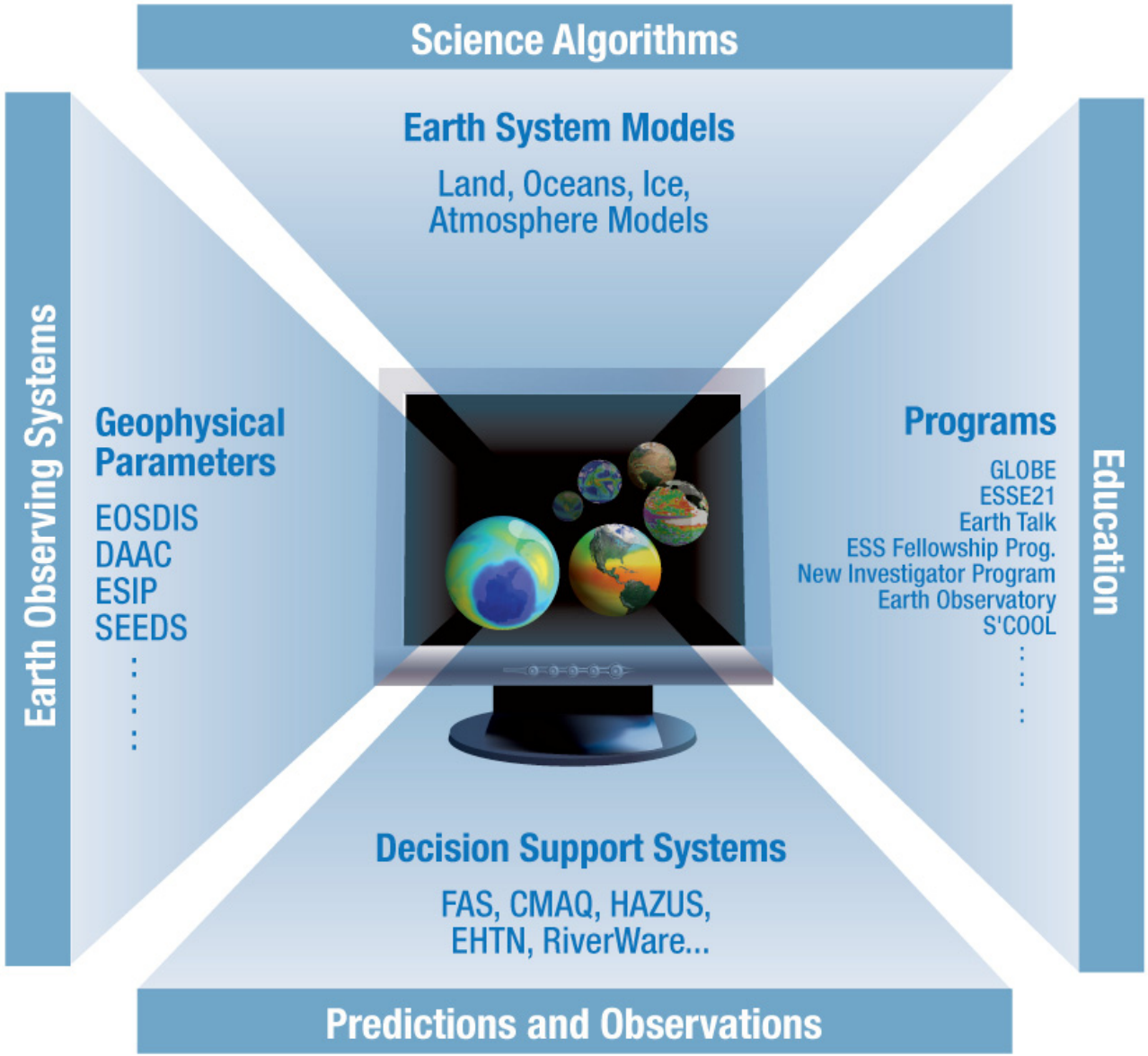


January 25, 2005

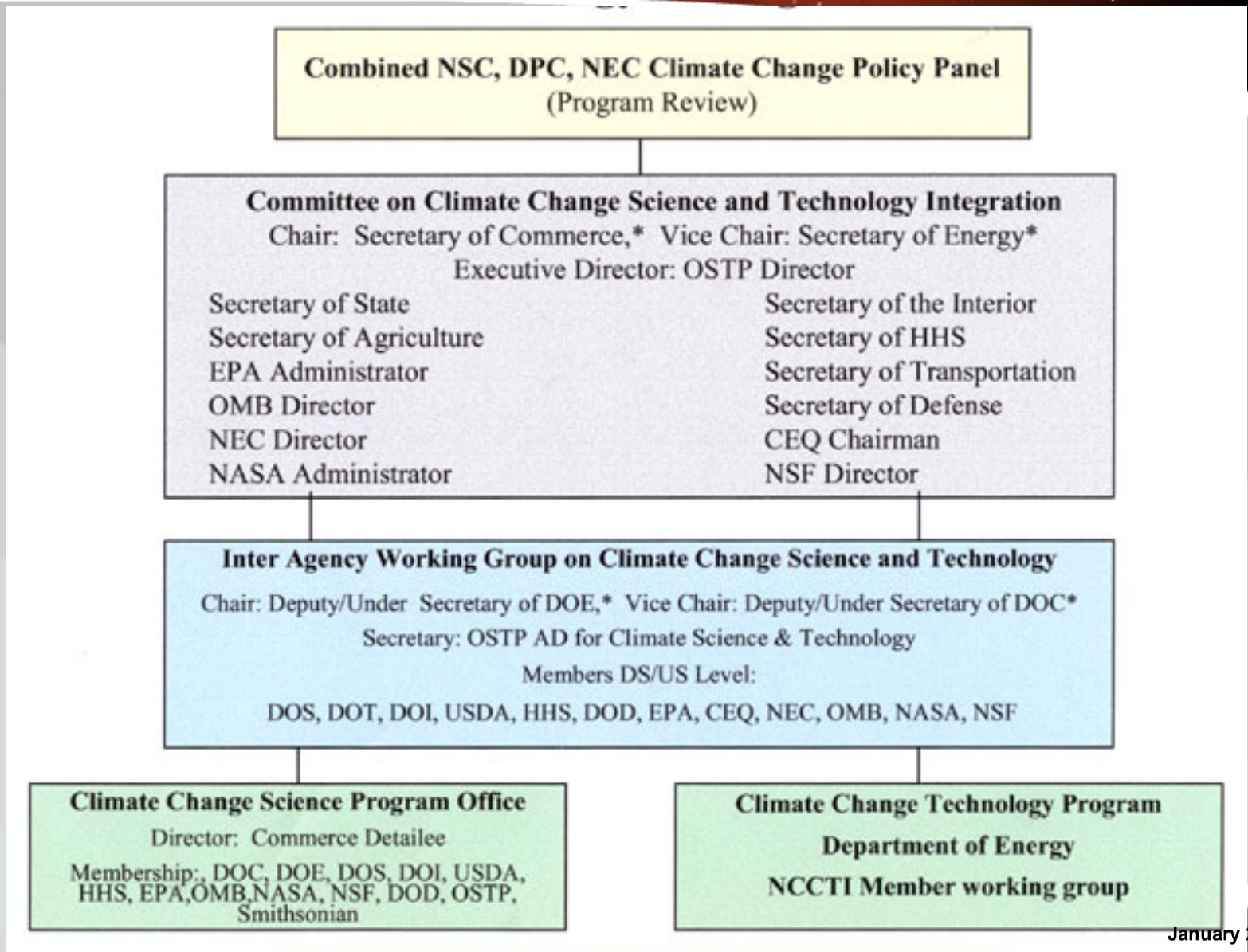
Transfer: National Lambda Rail



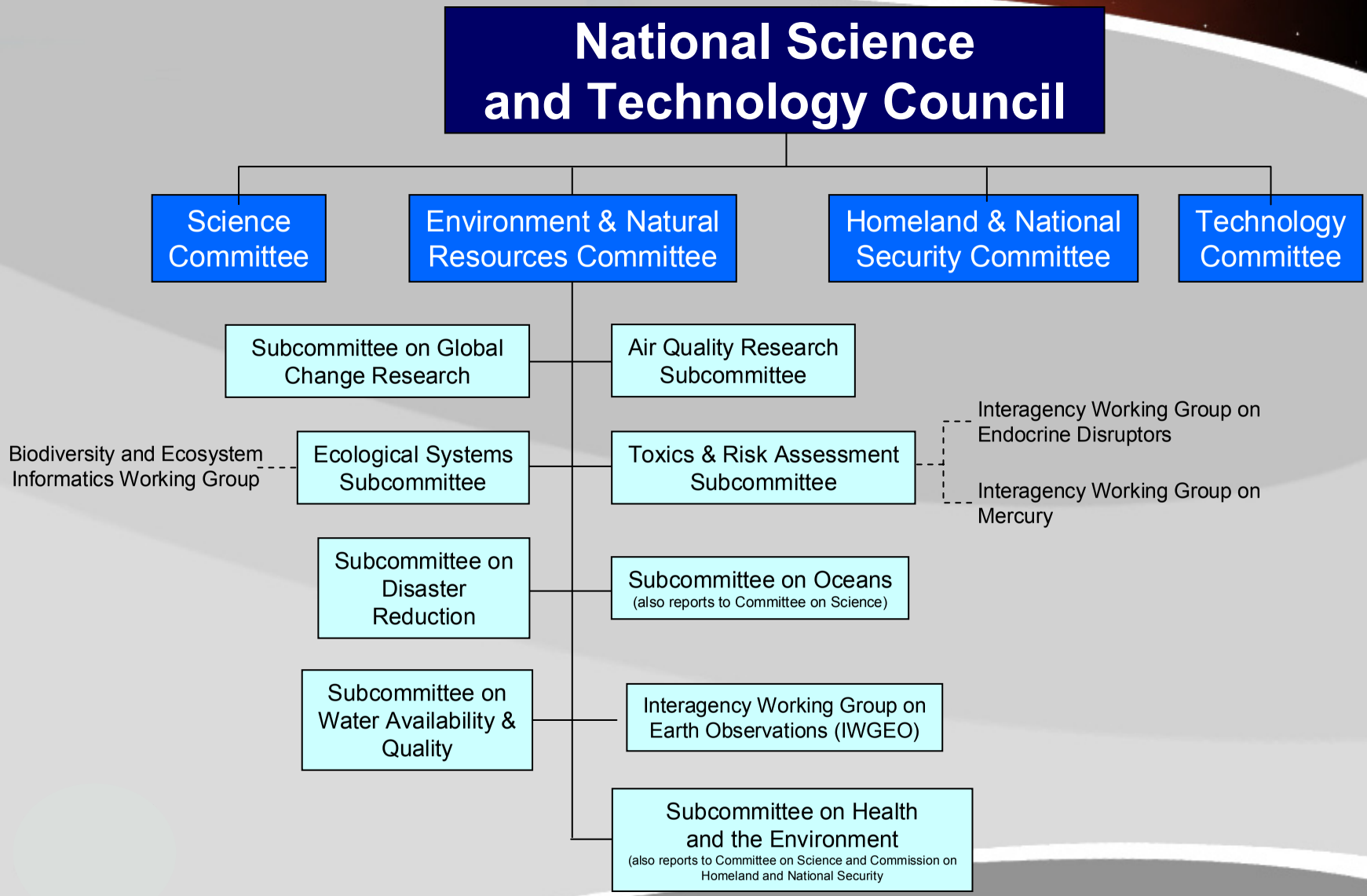
Access: Earth Science Gateway



Managing U.S. Climate Change Science & Technology



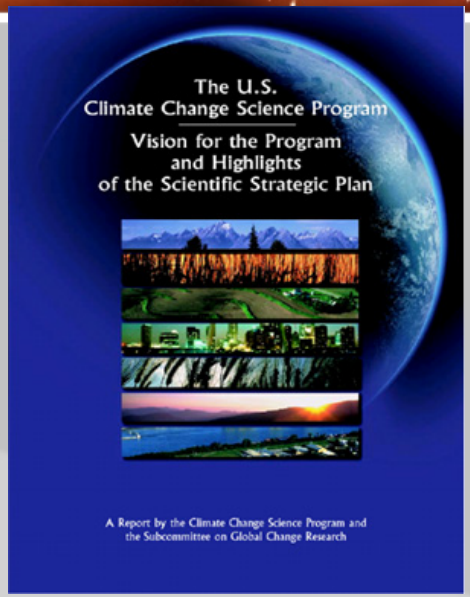
NSTC Structure

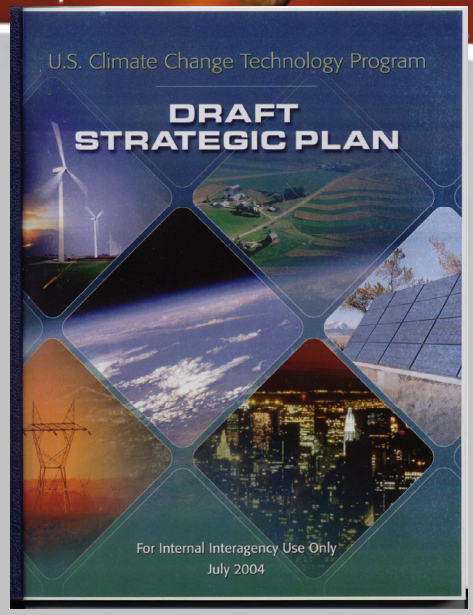


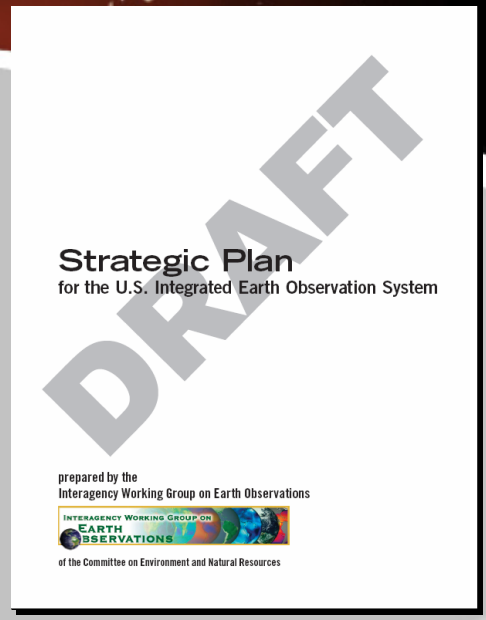
National Programs in a Global Context

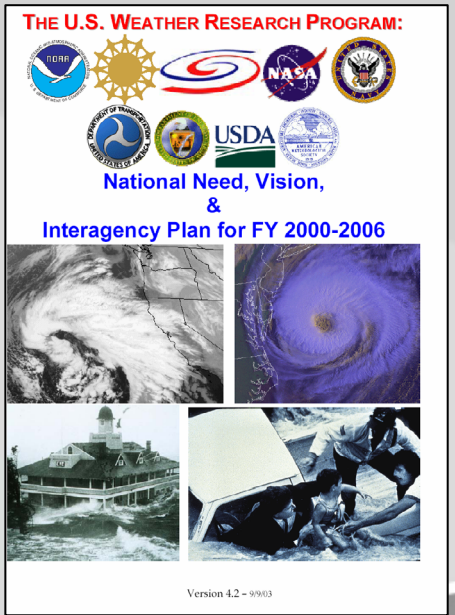
Priority	National Programs	International Programs
Vision for Exploration	Understanding the Earth as the foundation for Planetary Exploration and Search for Life	*"Pursue opportunities for international participation to support U.S. space exploration goals"*
Global Earth Observation	NSTC CENR Interagency Working Group on Earth Observations (IWGEO) Integrated Earth Observation System, 17 Agencies)	Group on Earth Observations (GEO) Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan
Climate Change	Climate Change Science Program (CCSP, 13 Agencies) Climate Change Technology Program (CCTP, 12 Agencies)	Intergovernmental Panel on Climate Change (IPCC))
Weather	U.S. Weather Research Program (USWRP, 7 Agencies)	World Meteorological Organization (WMO)
Natural Hazards	NSTC CENR Subcommittee on Natural Disaster Reduction (SNDR, 14 Agencies)	International Strategy for Disaster Reduction
Sustainability	CENR Subcommittee on Ecosystems	World Summit on Sustainable Development (WSSD)
President's Management Agenda: E-Government	Geospatial One-Stop (GOS, 12 Agencies) and the Federal Geographic Data Committee (FGDC, 19 Agencies)	World Summit on the Information Society

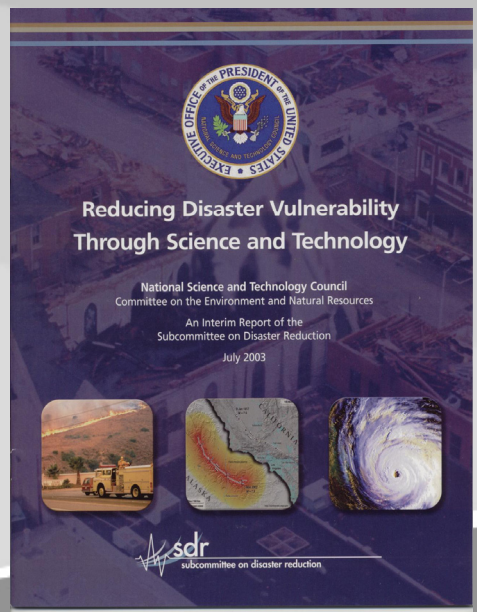
U.S. Plans for extending NASA Science Results

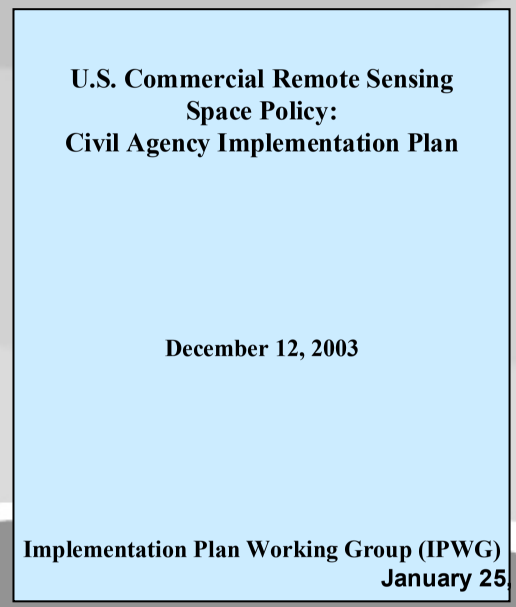












Earth-Sun System Science Components
www.asd.ssc.nasa.gov/m2m

John C. Stennis Space Center
Applied Sciences Directorate

+ View the NASA Portal
+ View Earth Science Enterprise

FIND IT @ NASA : + GO
+ ADVANCED SEARCH

Earth Science Enterprise System Components

Main Map

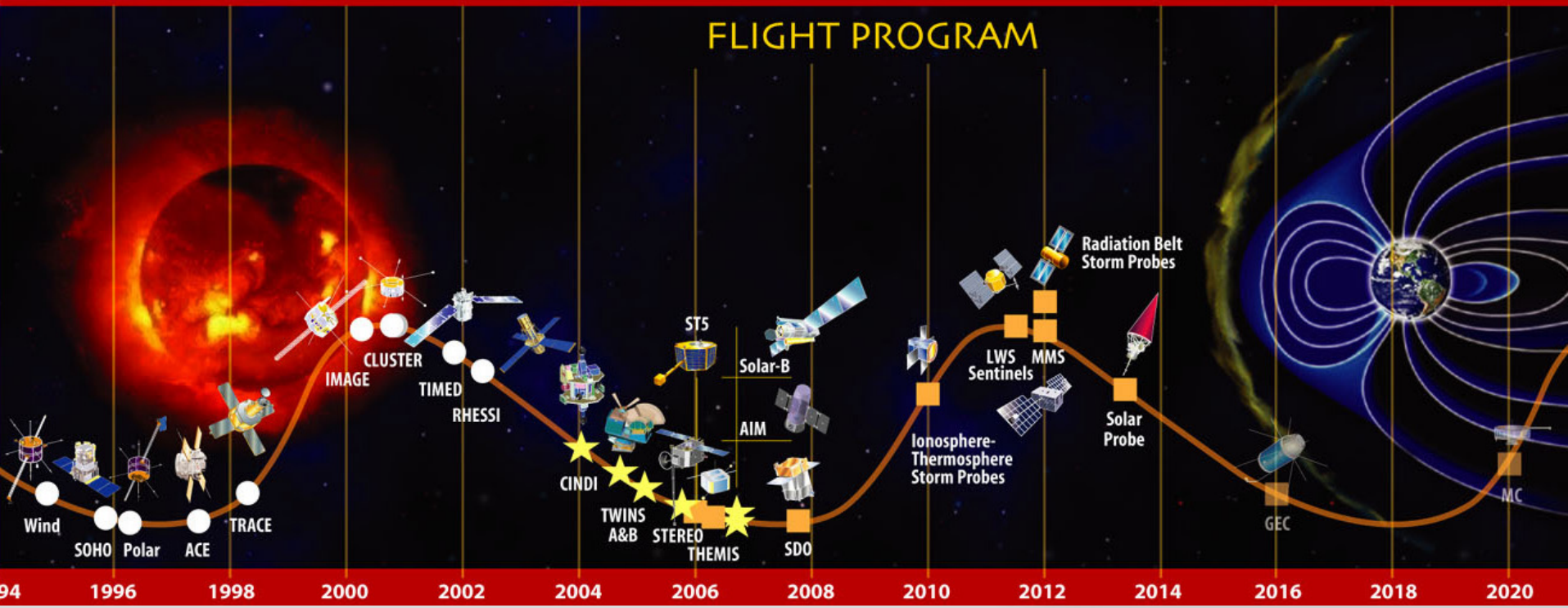
+ View Entire Diagram
+ Earth Observation Sources
+ Geophysical Parameters
+ Models & Analysis Systems
+ Model Outputs/Predictions
+ Decision Support Tools
+ Cross-Cutting Themes
+ Tools

+ Chart Legend
+ Chart Author
+ Comments/Corrections

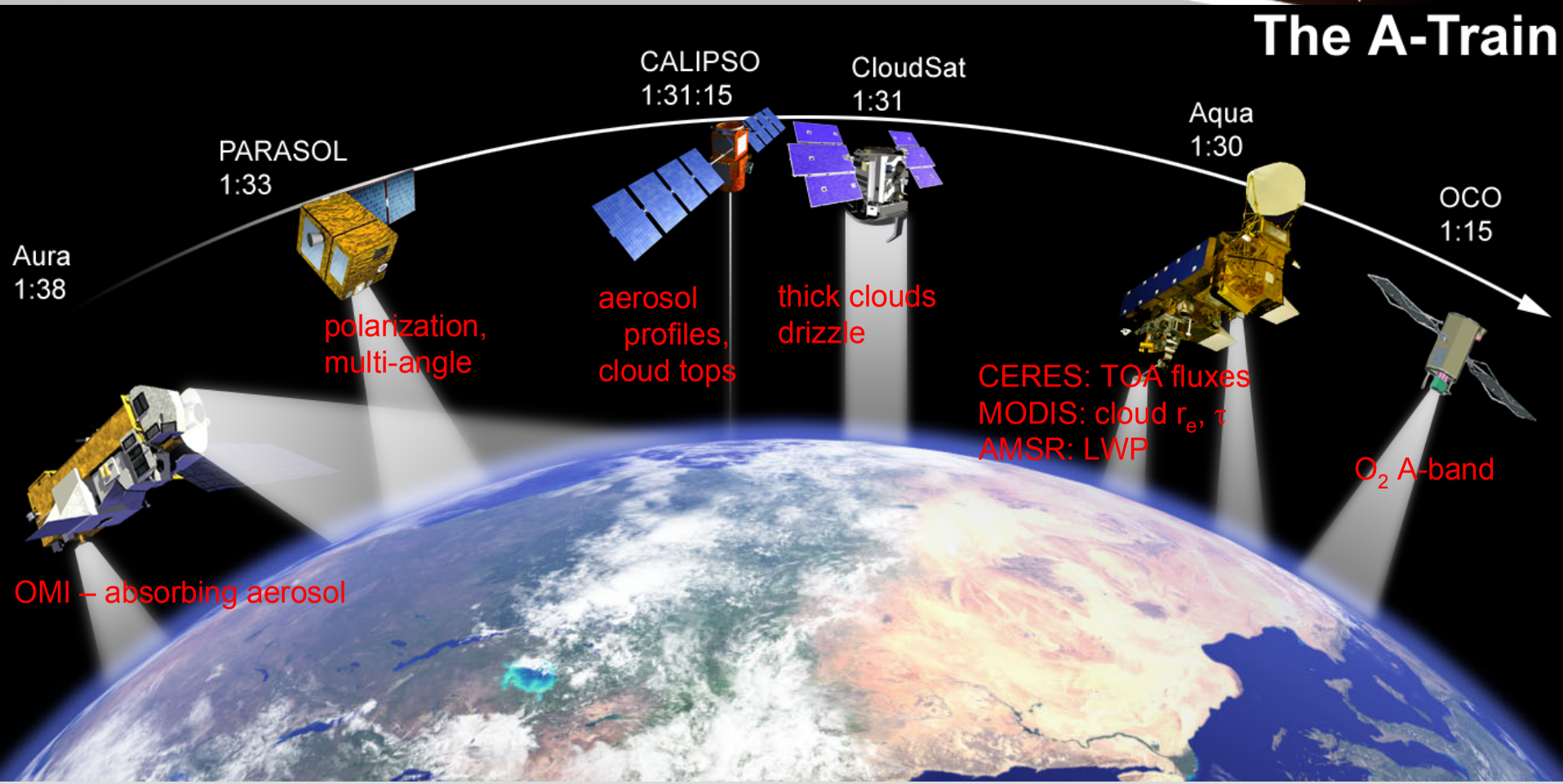
Earth Science Enterprise System Components Chart

January 25, 2005

Sun-Earth Connection Missions
Supporting Future Exploration



Earth Observation System A-Train: Aerosol/Clouds/Radiation



Earth-Sun System FY05 Budget

- $99 million for the Climate Change Research Initiative
- $141 million for development of the NPOESS Preparatory Project (NPP), 36% above FY04. NPP in full implementation & $42 million to maintain critical work on Landsat continuity
- $560 million for research, data analysis and modeling, 7% above FY04, allowing research on data from 80 sensors on 18 operating Earth observation spacecraft
- $240 million for missions in formulation, a 37% increase from FY 2004, including such missions as Orbiting Carbon Observatory, Aquarius, Hydros, and Glory
- $210 million for MODA, Research and Analysis, Sounding Rocket Program, and Multi Mission Support
- 204 million for LWS Program Missions, SDO and SET (confirmed), ITSP, RBSP, and SP in formulation
- $157 million for development of STP Program Missions, Solar B, STEREO, and MMS
- $212 million for Explorer Missions (Program Operated for the benefit of SMC), includes CINDI, TWINS, AIM, THEMIS and possible future SMEX selection

$ In Millions	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Earth-Sun System	**2,396**	**2,125**	**1,973**	**1,952**	**2,047**	**2,291**
Earth System Science	1,522	1,409	1,313	1,290	1,266	1,397
Earth Science Applications	91	77	77	77	77	77
Sun-Solar System Connections Science	**783**	**740**	**583**	**584**	**744**	**817**

How Does Your Work

Fit in?

Integrated System Solution Configurations for your projects

AVIATION SAFETY

NRA-01-OES-05-0225

Volcanic Aerosol Sampling

Alaska, Italy

JPL / SCRIPPS / CSIRO

Jet Propulsion Laboratory

The Scripps Research Institute

CSIRO

PRATA

ASH ALGORITHMS

Gas Abundance
Ash Abundance
Plume Altitude

TRANSPORT of VOLCANIC PLUMES

Volume / Concentration
Distribution

Data

ESE MISSIONS

Aerosonde – UAV

TOMS – SO_2
EO-1
MODIS
ASTER
TM
MTI

AVHRR / MISR
MIROR / ABAS

VOLCANIC PLUMES

SO_2 Measurements

DECISION SUPPORT TOOLS:

NWS – Alaska

Alaska

Volcanic Ash Forecasts

INGV – Italy

Istituto Nazionale di Geofisica e Vulcanologia

Proximal & Disaster Hazard Assessments and Warning

LANL / DOE / NWS / NOAA

FAA

AVIATION WARNINGS / ALERTS

CEOS / DMSG

Socio-Economic Benefits:

Pieri, David
Evans, Diane

$118 K

DISASTER MANAGEMENT

NRA-01-OES-05-086
Extreme Flood Events
Romania and Hungary

NATO OTAN

Dartmouth est. 1769

SCIENCE for PEACE

HYDROLOGIC MODELING

EHM
NIMH
VIDRA
CCRA
EFES

Suburban Flooding
- Snow Melt
- Rainfall
- Transfer
- Routing
- Attenuation

Data

ESE MISSIONS

- TRMM, AVHRR
- MODIS
- LANDSAT 7
- SRTM
- ASTOR
- RADARSAT
- ERS
- SPOT
- METEOSAT
- AVHRR

Topography
- Land Use/Land Cover
- Soil Moisture
- Precipitation
- Temperature

DECISION SUPPORT TOOLS:

Floodware:

Water Management & Protection

MSG / HRSA

ACOE / CRRRA

Romania:

- Crisuri Water Autico
- Inspector of Civil Protection

Hungary:

- Kovizig Gyula

Socio-Economic Benefits:

Brakenridge, Robert
NAG5-9470 $202 K
NAG5-10953

NRA-01-OES-05-023
Subsidence Monitoring
Lost Hills, California

Jet Propulsion Laboratory
California Institute of Technology

SCIENCE MODELS

UCB, LCB
FLUID FLOW

JPL

INTEROPERABILITY

SUBSIDENCE CHANGE

Data

MEASUREMENTS / MONITORING

GPS

INSAR (AIRSAR)

LIDAR (ATM)
GeoSar

RADARSAT
ERS
ENVISAT

⇨ ALOS PALSAR

TOPOGRAPHY

PST

SUBSIDENCE MONITORING

DOE / CHEVRON

UC BERKLEY and LAWRENCE BERKLEY

MODELING and CONTROL SYSTEM

DOE

CHEVRON

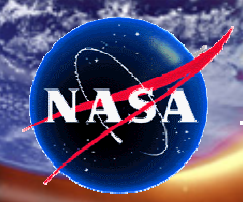
OIL FIELD OPERATIONS

Socio-Economic Benefits:

$100M NRC, 1991

Fielding, Eric
Blom, Ron

$317 K – NASA
$50 K - Chevron



DISASTER MANAGEMENT

NATURAL HAZARDS in FORESTS
WASHINGTON STATE
(Mt. Rainier, Mt. St. Helens)

USGS science for a changing world

Puget Sound Lidar Consortium

ACOE / CRRRA

SCIENCE MODELS

VOLCANO
NEO-TECTONICS
LANDSLIDES
EARTHQUAKE

VIRTUAL DEFORESTATION

FAULT MAPPING

- Sediment Transport
- Predictions
- Bald Weather Demo

Data

MEASUREMENTS

LIDAR (ALSM)

TERRAPOINT

Topography

DECISION SUPPORT TOOLS:

HAZARD MAPS

EQ PREDICTIONS
LS PREDICTIONS
V PREDICTIONS

USGS

EARTHQUAKE RISK ASSESSMENTS

PUGET SOUND

RISK & VULNERABILITY ASSESSMENTS

Johnson, Samuel
Haugerud, Ralph
$477 K

NRA-01-OES-05-031
Rapid Response with USDA FS RSAC Salt Lake City

UMBC

SCIENCE MODELS

NOAA

U of W:
IMAPP
MODO9

ATMOSPHERIC EMISSIONS AIR QUALITY

- Vegetation Condition
- Daily Fire Movement
- Change Detection
- Post Fire Recovery

EDOS *Data*

MEASUREMENTS

MODIS RR
ASTER
ETMT

QUICKBIRD
SPOT
IKONOS

MODIS FIRE PRODUCT

DECISION SUPPORT TOOLS:

USFS:

BAER
Fire Intensity Display

CACCS

Fire Maps / Progression

Nat'l Interagency Fire Center (NIFC)

NOAA

Air Quality Assessment

Transport Predictions

Brazil / Africa / Thailand

FIRE FIGHTERS

- Fire Mgt. Econ.
- Fire Impact Assessments
- Rehabilitation

NEWS CASTING:

- Air Quality
- Announcements / Warnings

Socio-Economic Benefits:

Sohlberg, Robert
Townshend, John
Justice, Chris

$902 K

DISASTER MANAGEMENT

EARTHQUAKE STRAIN MONITORING:
ORANGE, RIVERSIDE; CALIFORNIA

SCIENCE MODELS

- HPWREN
- ROADNET
- VPRG

REAL TIME DISPLACEMENT MAPS

DECISION SUPPORT TOOLS:

NGS / USGS / NASA / CSRC / SUPAC

SCEC:

USGS:

MANAGEMENT

COUNTIES

RCF KICD

CALTRANS

- RISK MGT.
- DISASTER MGT.
- STRUCTURAL MONITORING
- RAPID EARTHQUAKE RESPONSE

Socio-Economic Benefits:

Data

MEASUREMENTS

SCIGN – EPS SIGNALS

LOCATION DATA

Bock, Yehuda

$567.886 K

DISASTER MANAGEMENT

FLOOD & WILDFIRE FORECAST
LOS ANGELES, CALIFORNIA

Jet Propulsion Laboratory
California Institute of Technology

UCLA

SCIENTIFIC MODELS

PSU/NCAR MM5

MAS – WRF – AGCM – GFDL MOM

- QPF
- SMC
- RH
- SNOW MAID SST

NCEP

- ATM-STREAM MODEL
- LARGE SCALE FORECAST
- GCM

Data

MEASUREMENTS

- GPS SCIGN
- QUICKSAT
- AVHRR
- SEAWIFS

PROPERTY WATER MEASUREMENTS

DECISION SUPPORT TOOLS:

NWS

IFRS

VENTURA

VCFC

NOAA / NWS

FLOOD FORECASTS

FIRE FORECASTS

FLOOD OPERATIONS

FIRE OPERATIONS

Socio-Economic Benefits:

Kim, Jinwon

$640 K

FLOOD & DROUGHT FORECASTING:
YAKIMA RIVER BASIN

UMBC

Goddard Space Flight Center

SCIENCE MODELS

- LMS:
  - MOSAIL
  - NOAH
  - VIC-3L
  - CLM
- HYDROLOGIC MODELING
- NUMERICAL WEATHER PREDICTION
- SURPLUS ENERGY
- SOIL MOISTURE
- PAA

HYDROLOGIC FORECASTING

- Snow Depths
- SWE (Snow water equivalent)
- Runoff Simulation

Data

MEASUREMENTS

MODIS

SSM/I

AMSR-E

TRMM

GRACE

DECISION SUPPORT TOOLS:

B of R:

Riverware
Awards - ET

USGS:

PRMS
MMS

PFA: NOAA / USGS / TVA
ACOE / WSR – 88D

POLICY

- IRRIGATION POLICY
- WATER DISTRICT POLICY

MANAGEMENT

- FLOOD MGT.
- DROUGHT MGT.
- RESERVOIR MGT.
- IRRIGATION MGT.

Socio-Economic Benefits:

Arsenault, Kristi
Houser, Paul
Matthews, Dave
Sharp, Warren

$438 K

DISASTER MANAGEMENT

WILDFIRE FUEL MAPPING:
BOREAL FOREST of ALASKA

SCIENCE MODELS

- VEGETATION MOISTURE INDEX

FIRE POTENTIAL MAPS

DECISION SUPPORT TOOLS:

CFFPRS:

Fire Weather Index

PFA: USFWS / NPS / AWFCG / BLM / AFS

POLICY

MANAGEMENT

Fire Management

Socio-Economic Benefits:

Data

MEASUREMENTS

- RADARSAT
- ERS
- ENVISAT

SOIL MOISTURE MAPS

Bourgeau-Chavez, Laura

$670 K

ROSES - Decisions Solicitation

Purpose

Solicit projects a) to evaluate, verify, and benchmark solutions that integrate NASA Earth science results into applications of national priority and b) to improve networks of Earth science organizations to harness research results

Integrated System Solutions

Extend Earth science results to decision support systems in 12 applications of national priority

Projects need to present a clear understanding of the user community, its management or policy issues, and its decision support tools

Projects develop prototypes, validate and demonstrate system integration, and document performance

Solutions Networks

Improve ability of Earth science organizations to identify and harness results of Earth science research.

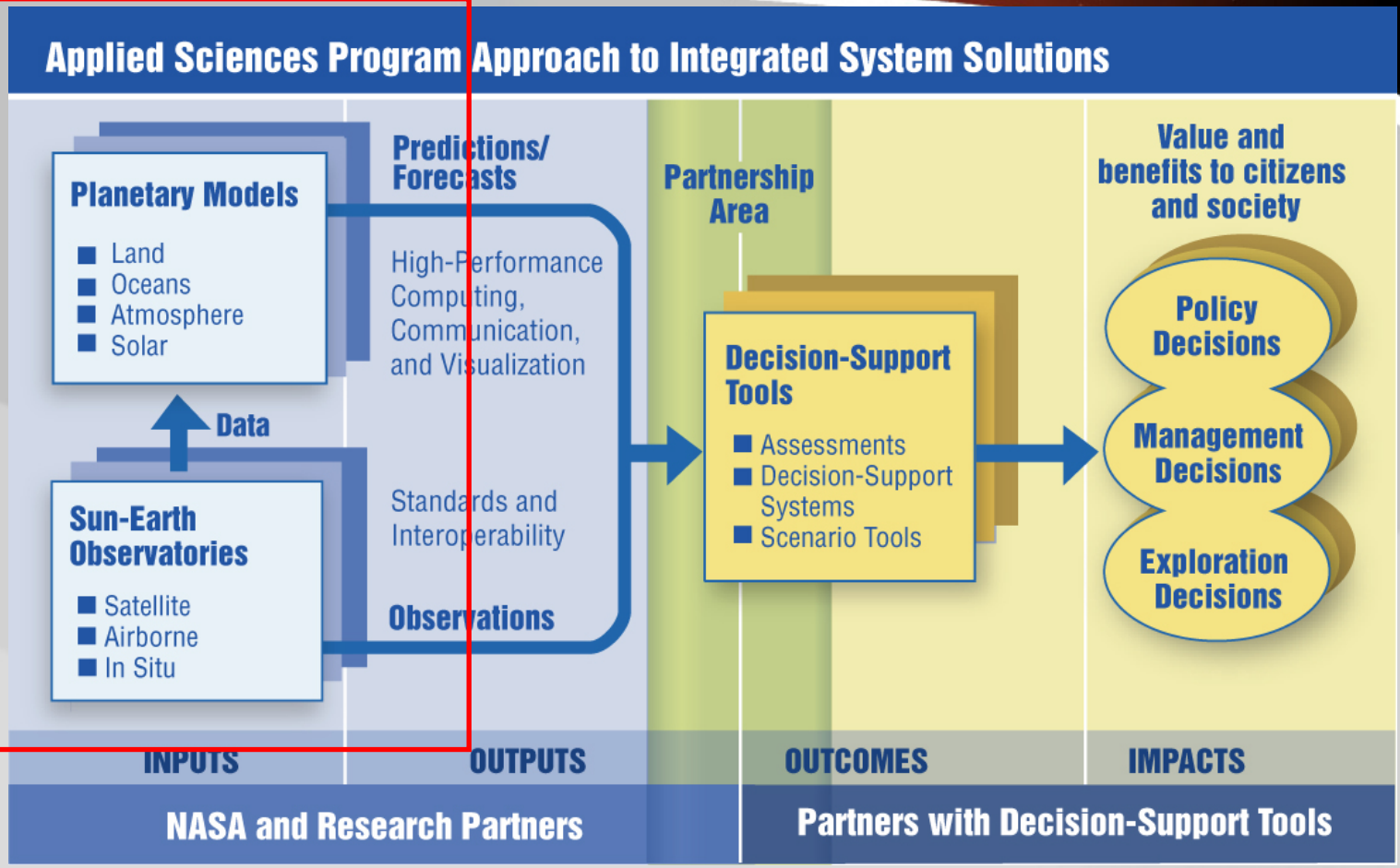
Primarily a “network-development” type of activity

Projects develop configurations to identify and optimize interactions between Earth science organizations

Projects identify and assess applicability of Earth science results

Applied Sciences Program
ROSES-Decisions Solicitation

Solutions Networks: Proposals to link Earth science organizations & mine results



Integrated System Solutions: Proposals to Link End-to-End

ROSES-Decisions Solicitation

General Information ***Amendment Pending****

Integrated System Solutions

- FY06-08 funds: $18 mil.
- # of awards: 12 - 30
- Award range: $200-450K per year
- Period of performance: 3 yrs.

Solutions Networks

- FY06-08 fund: $5 mil.
- # of awards: 2-6
- Award range: $250-750K per year
- Period of performance: 3 yrs.

The ROSES-Decisions solicitation indicates that:

1) the Program may transfer funds between the two components, depending upon the quality of the proposals.

2) Partner contributions do not count toward funding guidelines.

ROSES-Decisions Solicitation

2006 Emphasis

The ROSES-Decisions solicitation emphasizes:

- Use of an array of Earth-Sun System science research results
  - Variety of spacecraft observations, geophysical parameters, and model outputs

- Observations from sensors other than or in addition to MODIS and Landsat

- Use of Earth science model predictive capabilities
  - Integrating results (e.g., products, outputs, predictions) from Earth-Sun System science models
  - Especially models that use NASA spacecraft measurements as inputs

- Rapid prototyping

- Multi-sector (public, private, academia, etc.) teams
  - Strong role and involvement of the end users

ROSES-Decisions Solicitation

Expectations

Integrated System Solutions

Projects should develop prototype solutions, demonstrate them in an operational environment, and characterize system performance

Products

- Prototype
- System configurations
- Demonstrations
- Benchmark Report

Solutions Networks

Projects should develop network configuration analyses and diagrams, demonstrate network function, and analyze network performance.

Products:

- Network configurations
- Approach for Earth science results identification
- Demonstrations
- Performance analysis

ROSES-Decisions Solicitation

Schedule

Step 1 (Pre-Proposal) due	Change pending to July timeframe
Step 1 Review	July-August
Step 1 Notification *(encourage/discourage)*	Mid-August
Step 2 (Final) proposal due	Change to October
Review Panels	December
Announce awards	January 2006

Thank you for coming!

Additional Information

Agricultural Efficiency

Global Agricultural Production Assessments

January 22, 2004,
E. Sheffner

Socioeconomic Impact

Enhanced DSS integrating new generation image products, precip. data, and crop models for more accurate crop production assessments

Transition to NPOESS with cross calibration to legacy systems. Integrated system to ingest data from wide variety of commercial high-resolution systems.

Outcomes: Better information on hot spots

Impacts: Long-term operational sustainability that exploits all available systems

Transition to VIIRS/NPP, and other new data sources as they come on-line. Integrate data into operational systems. Benchmark new capabilities.

Outcomes: New tools to exploit enhanced capability for region-specific modeling and prediction. Ability to compare new data to archive

Impacts: More accurate crop assessments based on new operational capabilities

Evaluate, via data simulations, new data sources (OCO, Aquarius, HYDROS) on predictive capabilities and production estimates.

Outcomes: New tools for analysts to exploit enhanced system capability for region-specific modeling and prediction

Impacts: More accurate production estimates

New MODIS-based vegetation, ET, and TRMM products for CADRE database and crop models

Outcomes: New source of precipitation and land cover data to analysts offering more comprehensive knowledge base for in-season crop monitoring

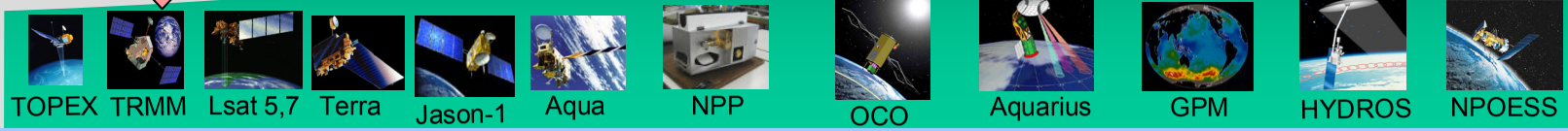
Impacts: More accurate and timely drought monitoring. Enhanced prediction of yield

Rapid Response Delivery system for daily MODIS products. Reservoir stage products.

Outcomes: New source of data available to analysts offering unprecedented spatial, spectral, and temporal coverage

Impacts: More accurate acreage and production assessments. Earlier detection of potential problem areas

CADRE: DSS that integrates Landsat & AVHRR with limited crop models and coarse gridded weather data



Current — 2006 — 2008 — 2010 — 2012

Enhanced operational decision support system for prediction and monitoring of agricultural production.

January 25, 2005

Air Quality

Clean Air Standards and Air Quality Forecasts

State 2 (c. 2015): ESMF
- Robust emissions control planning
- Routine warnings of pollution events
- Multiple-day air quality forecasts

January 2004,
L. Friedl

Socioeconomic Impact

Simultaneous high-time & space resolved pollutants (O3, CO, NOx, SO2, HCHO, aerosols); local resolution in boundary layer. Nighttime chemistry & transport. Feedbacks betw. aerosols, O3, H20, climate. Chem-radiation coupling in GCMs. Quantify LRT in regional pollution.

Accurate pollution forecasts updated regularly within day. Reduced hospital visits from extreme events. Improved NAAQS planning - fewer non-attainment areas. Insight on mobile emission fluctuations. Advanced, targeted mitigation of impacts from severe episodes.

NPP-NPOESS - ozone trend & aerosols. Feedbacks between O3, H2O, and aerosols. Global trop. winds. Geographic evol. of trop. O3 & aerosols. Lightning NOx emission inventories. Trop. mixing & BL interaction. Urban-scale heat flux. High-res. soundings.

Clear Skies NOx/SO2 Trading Program. Longer lead-time on source & destination of ozone and aerosols. Alerts to re-route airplanes. Alerts to hospitals to expect specific symptoms. Ozone attainment areas. Potential EPA SIP credits for heat island reduction approaches & corresponding state/city policies.

CloudSat & CALIPSO - cloud profiles. Accurate energy & water in MM5. Vertical levels in lower troposphere. Models incorporate radiative forcings. Land-atmos. interactions. Chemistry-transport models. Stratospheric/trop. coupling. Chemistry-climate interactions.

Forecasts of beginning & length of annual "pollution season." Improvements from achievable SIPs - reduced haze, improved visibility in parks, cleaner water, healthier forest ecosystems, reduced lost work/school days. Support US treaty on long-range transport of organic pollutants.

AURA - SO2, NOx, NH3 and aerosol products & IMPROVE network. INTEX-West. NH3 emissions factors; air dispersion models (NOx, CO, PM); MM5 & assimilation of surface moisture, heat capacity, insulation. Nested model developments. RAQMS & DAS for daily 3-D ozone.

Support for goals of Clear Skies initiative. Science-based attribution of source emissions. States quantify voluntary stationary emission reductions within 18 months. Heat island effects in local weather and air quality forecasts. Longer-term AQI forecasts. UV-B notice.

AURA - AURA - AURA. Trop. residuals (O3, NO2, SO2, HCHO); NRT NOx & VOC emission inventories (top-down/bottom-up) for CMAQ & ozone precursors; O3 assimilations in CMAQ; 3-D global trop. chemistry in GEOS-CHEM; aerosol pattern rendering.

Support 2004 NOx SIP call. State justify & EPA corroborates claims for foreign-born pollution waivers. Annual EPA analysis of worst 20 pollution events for trends. Extend PM/O3 forecasting to rural areas - warnings to farmers. Targeted mitigation approaches. Ozone loops in EPA's AQI.

INTEX continental inflow-outflow; ICESat - vertical distribution of dust & clouds; ASTER urban heat flux; Global-to-regional RAQMS - prototype BCs in CMAQ; DAS nested GCM to 0.5º grid. Pollution trajectories & BL deposition of LRT of aerosols. PM network.

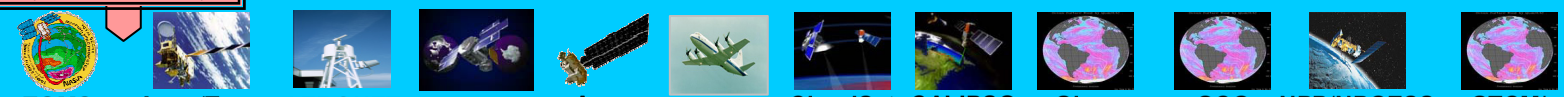
States assess emissions control options, development options &emissions strategies to build attainable SIPs. Achievable SIPs improve air quality, public health & economic development opportunities. Urban health alerts for temperature-induced pollution events. EPA guidebook on heat island reduction approaches. States claim waivers for foreign-born pollutants.

MODIS AOD, MOPITT CO, TOMS ozone residuals - correlate to EPA ground measures. Large scale transport of aerosols. GOCART assimilations for B.C.s in models. NRT MODIS-TEOM data fusion.

Policy-Forecasts-Health-Economics. Aerosol transport loops in EPA Air Quality Index (AQI) for regional forecasts. Improved siting for surface monitoring network locations. Support EPA-developed tools for state/locals on regional haze. Evaluate exceptional events for effects on NAAQS violations. EPA PM transport rule making.

State 1 (c.2003)
CMAQ & AIRNow-AQI

Improved capabilities to air quality managers to assess, plan & implement sound-science, emissions control strategies, policy, & air quality forecasts.



TOMS | Aqua/Terra | AERONET | ICESat | Aura | INTEX | CloudSat | CALIPSO | Glory | OCO | NPP/NPOESS | GTCM*

2003 2005 2007 2009 2011 2013 2015

* Unfunded

January 25, 2005

Aviation

Earth Science research results improve wx products for the NAS

January 21, 2004,
J. Haynes

$2B/year

Partners:

State 2-**WX Visualization Systems**: Fully integrated **SVS, WARP & ITWS** in-cockpit graphical WX displays featuring real-time weather information with global coverage

State 2- **WX Sensors/Data Sources: AIRS, CrIS & GIFTS** fully integrated into **NEXRAD & TDWR** systems; prepared for seamless integration of **ABS** (GOES-R)

Socioeconomic Impact

EOS, NPP, NPOESS & GOES-R

NAS-wide Data Link WX Products provide severe weather location and movement data to controllers and aircrews to promote common situational awareness

GIFTS – Geosynchronous Fourier Transform Spectrometer Turbulence & Weather Prediction Modeling

Geostationary satellite technology improvements will vastly improve remote measurement of altitude-resolved vector winds and temperatures, allowing for efficient flight planning, operations and traffic management.

Aqua and NPP fly the AIRS and CrIS sensors (Atmospheric Infrared Sounder and Crosstrack Infrared Sounder)

High spectral (vertical), horizontal and temporal resolution satellite measurements will render precise numerical weather forecasts and extremely high-resolution wind fields based on the tracking of atmospheric water vapor

NAST (I) Atmospheric Sounder Testbed Infrared (Proteus) Experiments

Airborne validation of NPOESS instruments provides DSS product development teams with experience at integrating hyperspectral data and information in preparation for subsequent GIFTS and GOES-R missions

Advanced Satellite Applications Products (ASAP) Program

Integration of existing GOES imagery and sounding data into AWRP products improve CIP/FIP, Terminal Convective WX product and Integrated Turbulence Forecast

State 1-**WX Visualization Systems**: Discrete, Stand-alone weather products, with little satellite sounding data or imagery

State 1-**WX Sensors/Data Sources:** Ground Doppler Radar, 2x daily balloon readings yield 6 to 12-hour forecasts; poor oceanic coverage

Current trajectory:

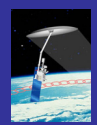
Steady improvement in fielding and integration of hyperspectral LEO and GEO satellite data into NWS aviation weather products and AWRP visualization systems, resulting in fully integrated, real-time global aviation WX coverage

GOES-L,-M

Proteus

Aqua

NPP/VIIRS


HYDROS

GIFTS

*NPOESS

GOES-R

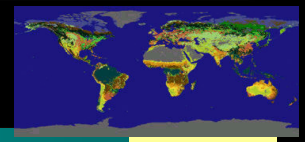
*Pre-formulation

2000 2002 2004 2006 2008 2010 2012

Enhanced Aviation Weather DSS and synthetic vision systems that reduce the aviation fatal accident rate by a factor of 10 by 2022

January 25, 2005

Toward a Carbon Management Regime



January 12, 2004,
E. Sheffner

Socioeconomic Impact

Next Global land cover and change products

Assess and predict sink duration and (credit longevity) for different land uses

Soil Surface Moisture Measurement

Modelling of soil carbon storage as a function of soil fertility and vegetative processes

Forest height & canopy volume sampled globally. First global land cover change data product

Capability for volumetric assessment of above ground carbon sinks (3-D vs former 2-D capability) Potential to reduce frequency of costly *in situ* measurements

Global atmospheric CO_2 from OCO

Improved accuracy in measurements of carbon fluxes and monitoring of carbon storage in above ground biomass, lakes and coastal environments

N. American Carbon Program and related international results incorporated into models (w/ C data assimilation).

Regional monitoring of carbon storage in biomass and soils
Regional assessment of candidates for carbon sequestration projects

Exploratory studies to extract atmospheric CO_2 from existing satellite sensors; coupled atmospheric-terrestrial model

Assessment of carbon sink strength at continental scale
Capability to discriminate between land and atmospheric carbon fluxes

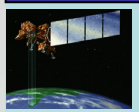
EOS & global land cover observations; Carbon data model assimilation

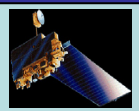
Baseline information and dynamics of terrestrial carbon sources and sinks. Initial 1605(b) input from MODIS data.

Current trajectory

Steady improvement in model coupling, process characterization, assessment of carbon sources and sinks

Prototype Carbon DSS

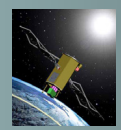

Landsat 7

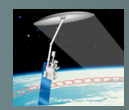

Terra

Aqua

Aura

NPP


OCO


HYDROS

NPOESS

2004 2006 2008 2010 2012

Validated decision support tools for measurement and monitoring of carbon storage in terrestrial and aquatic environments

01/09/04
January 25, 2005

Coastal Management

Resources Monitoring & Impact Forecasting

Coastal - State 2 (c. 2015)
- Routine prediction of HAB events.
- Increased response time for oil spills
- Mitigation of coral bleaching events.
- Improved management decisions for sediment transport near coasts.

January 12, 2004,
L. Freidl

— $1 Billion / 10 years

Primary Partners:

NOAA EPA ONR

Socioeconomic Impact

ATMS– global temperature and moisture profiles. VIIRS –SST, ocean color/chlorophyll measurements, turbidity, suspended matter concentrations, littoral sediment transport at < 1km resolution.

Increased spatial/temporal coverage of coastal remote sensing & modeling for reduced impact of pollution, spills to protected & commercially important coastal resources (reefs, fisheries). Routine forecasting of HAB events, climate-induced coastal change, other natural phenomena impacting coastal environments and property.

Aquarius LBR/LBS monthly, global sea surface salinity mapping (within 0.2 psu). DPR/GMI 3-hr global precipitation data & 4-D structure of rainfall rates. GCOM ocean vector wind mission – improvements to coastal OGCM.

More accurate prediction of sediment & freshwater input to coastal waters, improvements in coastal circulation modeling for HAB prediction & tracking, fisheries management. Prediction of conservative mixing region for point source pollution into coastal waters – improved forecasting abilities for resource managers, public health officials, and hazard response teams. Improved measurements of storm surge and coastal inundation for emergency response planning.

Improved 3Dvar ocean circulation models with Grace KBR geoid estimates. OSTM DORIS/TRSR sea surface state & ocean tides – short-range circulation products. Input to GODAE operational demonstration products.

Higher spatial/temporal resolution of coastal models for improved fisheries management, HAB tracking. Better projections of shoreline erosion for flood and coastal storm damage reduction. Chlorophyll advection product for improved HAB forecasting. Coastal dispersion models for oil spill tracking – improved mitigation strategies for hazard response teams. Bleaching indices for coral reef health estimation – advanced warning to sanctuary managers.

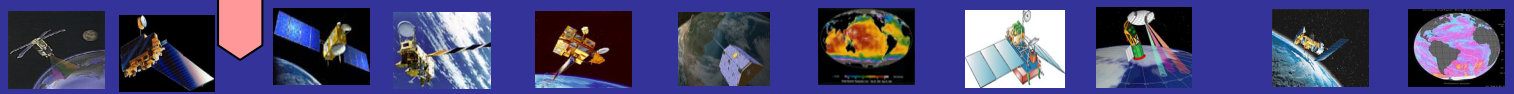
MODIS phytoplankton, DOM, & SST. SeaWiFS ocean color. AIRS & AMSR-E SST. SeaWinds & AMSR-E surface wind fields. JMR/Poseidon2/DORIS SSH, waves, sea level. Correlation with GOOS data.

Chlorophyll products for HAB detection – increased lead time for shellfish managers and public health officials. Identification of coastal sediment flux around coral reefs & depth-classification algorithms for coral reefs – accurate reef mapping for sanctuary managers and warnings of environmental conditions detrimental to reef health. Synoptic spatial/temporal coverage of coast – large oil spill & hurricane tracking for damage analyses.

Coastal - State 1 (c. 2003)
HAB Bulletin, CREWS, GNOME.

Current trajectory:
Steady improvement in coastal-ocean measurements and circulation models.

Improved capabilities to coastal resource managers for prediction and analysis of impacts to environmental and economic resources.



SeaWiFS	Terra	Jason-1	Aqua	QuikSCAT	GRACE	OSTM	GPM	Aquarius	NPP/NPOESS	OVW *
2003		2005		2007		2009		2011	2013	2015

* Pre-formulation

January 25, 2005

Disaster Management

HAZUS-MH - Risk Assessment and Loss Estimation

State 2- Improved
Hurricane prediction
Flood prediction
Severe Storm prediction
Wildfire prevention and prediction
Earthquake prediction

January 12, 2004,
S. Ambrose

Primary Partners:

Socioeconomic Impact

Transfer of advanced event-modeling capabilities using next-generation hardware, software, and communications

Outcomes: Improvement of FEMA capabilities across all hazards and phases

Impacts: Reduce losses across all disasters

Land use/Land cover, changes in earth's surface topography and Improved geodetic imaging, ocean measurements to track hurricanes

Outcomes: Improvement of FEMA planning, and response capabilities to weather and natural hazards

Impacts: Reduce losses across all weather-driven Disasters and earth movement

Improved measurements of soil moisture, global precipitation, water vapor, and wind

Outcomes: Improvement in wildfire prediction, HAZUS-MH High Winds Module Final Version

Impacts: Reduce losses related to hurricane, fire, and high wind disasters.

Understanding of Earth's gravity field And terrestrial reference frame changes in geomagnetic field and understanding of sea level change and climate

Outcomes: Improvement of the HAZUS-MH earthquake assessments And flood inundation for coastal areas

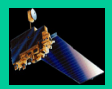
Impacts: Reduce losses related to hurricanes and earthquakes.

Production of assimilated data sets, reanalysis of long period observations

Outcomes: Improvement in climate data and information for risk assessments

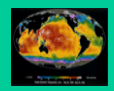
Impacts: Reduce losses related to flood and wind disasters. Better community planning

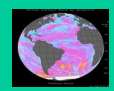
State 1- Earthquake Damage assessment

QuikSCAT

Terra

Aqua

TRMM

SeaWinds

OcnTopo

Hydros

* OSWinds

Aquarius

NPOESS

* Pre-formulation

2004 2005 2006 2008 2010 2020

An operational decision support system for quantification and verification of solutions for natural hazard predictions.

January 25, 2005

Ecological Forecasting

Socioeconomic Impact

Integration of remotely-sensed data with various model types, e.g.: ecosystem, ecological niche, population & habitat viability, biogeography, biogeochemistry, & regional ocean & atmospheric models -- as well as the development of new predictive models

"If-Then" Scenarios for Ecosystem Responses to Change/Disturbance

January 12, 2004,
W. Turner

Ongoing global land cover change product; global precipitation data

Species Distribution Forecasting System > biodiversity/stability/ productivity links

Soil surface moisture, sea surface salinity, global river discharge

Species distribution models with improved accuracy

Vegetation structure & disturbance from active sensors; new data on physiology & functional groups (hyperspectral/fluorescence)

Operational SERVIR, Protected Areas Management System, & Marine Fisheries Forecasting System DSS's

Regional ocean models coupled to ecosystem models; global land cover change product

Prototype Marine Fisheries Forecasting System DSS for fisheries management; also Protected Areas Management System DSS incorporating species habitat & demographic data into a planning tool

Prototype predictive models linking remotely-sensed environmental parameters to changes in terrestrial & aquatic ecosystems

Initial operation of Regional Monitoring & Visualization System DSS (SERVIR) for environmental management & sustainable development in Central America

Current trajectory

EOS & global land cover observations; early coupling of regional climate & ecosystem models

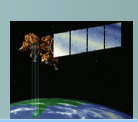
Assessment of land cover change/climate impacts on ecosystems

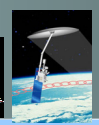
Steady improvement in models linking functional, structural, spatial, & temporal environmental measurements (ongoing measurements include: land cover, ocean color, primary productivity)

Operational ecological forecasting systems supporting environmental & natural resource management for sustainable development

TRMM

SRTM





Landsat 7 Terra Aqua NPP/VIIRS LDCM Aquarius GPM HYDROS NPOESS

2003 2005 2007 2009 2011 2013

January 25, 2005

Energy Management

Global long-term time series of industrial parameters; forecasted weather products for short-term (1-5 day), mid-term (10 day – 90 day), long-term (1-2 year) and climate.

January 16, 2004,
G. Stover

Socioeconomic Impact

Global Temperature/Moisture information assimilated into forecast and analysis models; improved mid/long-term forecasts

DSS improved with short/mid-term forecasts; long-term forecasts; soil moisture for biomass

Improved precipitation products (TRMM,GPM); Analysis of global precipitation and energy fields (GMAO); Forecasted parameters (NASA,NOAA)

DSS improved with parameter accuracy in time series & short-term forecasts; mid-term forecasts; addition of precipitation (biomass-fuel support).

Cloud Vertical Profile Statistics (CloudSat); Global aerosol distributions (Calipso)

DSS improved with); 1st short-term forecast of industrial parameters

Cloud, aerosol, energy data (Terra/Aqua) to improve/extend time series and evaluate/improve model forecasts; improved reanalysis (NASA GMAO)

DSS improved due to increased accuracy of energy (solar and infrared) and meteorological (temp., humidity, winds, clouds) parameters; near-term analysis

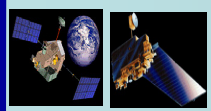
Increased resolution and extended time series (SRB and SSE)

DSS improved with 1st 12-year time series data set of industrial parameters with worldwide coverage at 1° x 1° resolution

Surface site climatological mean input data, coarse resolution global data; little weather forecast data

Incremental improvement in weather and climate forecasts from 1-2 day to 1-2 year predictions.

By 2012: Optimization of systems for the development of:
- renewable energy systems (including integration into power grid),
- energy-efficient buildings (construction, renovation, operations),
- biomass crop selection and maintenance strategies, and
- electric power load and supply assessments

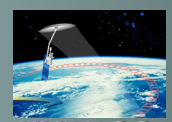

TRMM

Terra

Aqua

CloudSat/Calipso

GIFTS


HYDROS

GPM

NPOESS

2000 2002 2004 2006 2008 2010 2012

January 25, 2005

Homeland Security

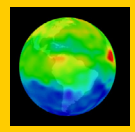
DHS Situation Center Prep.: Mitigation, Warning, & Response

State 2-DHS Situation Center (c. 2012):
- Prepared with integrated data streams
- Information for warnings & alerts
- Rapid data to support responders and officials with info & analysis

January 12, 2004,
S. Ambrose

Primary Partners:

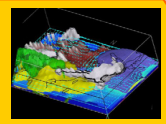
- Day/night air monitoring
- Trace gas measurements
- Improved circulation models



Outcomes: Streamline tasking for priority threats and flow of information.

Impacts: Reduce major illnesses and deaths from events.

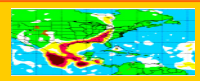
- Deposition Analysis
- Food security detection sensors
- Plume transport visualizations



Outcomes: Rapid identification of air/water biological agents. Trace sources & destinations Issue health alerts.

Impacts: Manage public reaction, fear, and over-reaction.

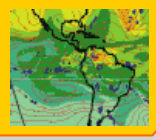
- Plume chemistry and speciation
- Robust satellite data assimilation
- Aerosol & trace gas characteristics



Outcomes: HAZUS-MH Improved information for first responders and recovery efforts. Warnings to food handlers & water treatment plants.

Impacts: Reduce exposure to first responders. Minimize extent of economic impacts.

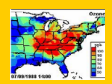
- Visualization/interoperability
- Effects of global atmospheric chemistry on regional air quality



Outcomes: Identify downstream exposure to airborne/waterborne contaminants. Increase warning time to people/officials .

Impacts: Reduce health effects and exposure. Reduce hospital admissions and lost productivity.

- Earth Science results analysis
- Risk assessment
- Model development



Outcomes: Model coordination and planning for specialized models. Coordinate with Homeland Security Tiger Team

Impacts: Minimize subsequent exposure to populations and secondary effects.

Current trajectory:
Improvements in plume modeling, risk assessment, sensor capabilities, visualizations and damage assessment.

State 1-DHS Situation Center (c. 2004):
Early formation stage.

QuikSCAT

Aqua

TRMM

GRACE

Aura

CloudSat

Hydros

Aquarius

NPOESS

GIFTS

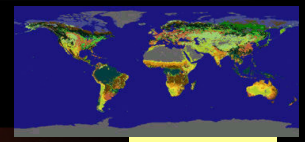
2004 2005 2006 2008 2010 2012

Socioeconomic Impact

Improved capabilities to Department of Homeland Security to prepare, warn, and respond to homeland threats, especially air and water exposure.

January 25, 2005

Invasive Species



Management and Prediction

January 12, 2004,
E. Sheffner

Soil Surface Moisture Measurements products (HYDROS)

Invasive species spread as a function of soil fertility & veg. processes

Next Global land cover & change products

Capability to assess & predict patterns of species invasion & biodiversity for different land uses

Global Atmospheric CO_2 from OCO and other sources

Capability to link biotic potential & diversity to carbon storage & flux

Forest height, perimeter & canopy volume sampled globally. First global land cover change data product

Capability for assessment of complex structural habitats (3-D vs former 2-D capability)
Capability for terrestrial & aquatic prediction

N. American Carbon Program & related international results incorporated into models (w/ C, climate) & ecosystem data assimilation. Canopy structure from LIDAR

Continental assessments of native & exotic plant diversity
Probable locations of rare habitats & potential areas for future invasion

Exploratory studies to map biological resources using existing satellite sensors; coupled atmospheric-terrestrial models

Regional assessments of native & exotic plant diversity
Capability to discriminate between potential "hot spots" of native & exotic plant diversity

EOS & global land cover observations; Carbon & climate model assimilation

Baseline information & dynamics of major terrestrial plant invasives

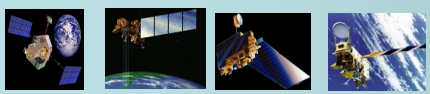
Prototype Invasive Species DSS

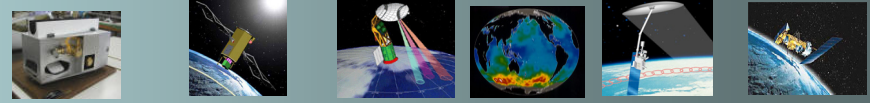
Current trajectory

Steady improvement in model coupling & enhanced functional, structural, spatial, & temporal environmental measurements

Socioeconomic Impact

An operational National Invasive Species Forecasting System for early detection & monitoring of biological invasions


TRMM Lsat 5,7 Terra Aqua


NPP OCO Aquarius GPM HYDROS NPOESS

2004 2006 2008 2010 2012

1/09/04
January 25, 2005

Public Health

State 2 - Public health surveillance systems able to track weather-climate-environmental factors to improve disease outbreak predictions, increase warning time.

January 7, 2004,
R. Venezia

Primary Federal Partners

CDC SAFER • HEALTHIER • PEOPLE™ | National Institutes of Health | Department of Defense

Data standards, workforce development support sustained integration of data and models.

Surveillance systems have automated ingest of data and models. Public health decision support systems benchmark use of Earth system science.

Integration of Earth system science data and models into surveillance systems. Visualization of weather / climate / environmental data.

Surveillance systems validate data and models for use in surveillance. Visualization technology enhances public health risk communication.

Chronic and infectious disease models coupled with Earth science models.

Predictive capacity of Earth system science data and modeling verified for specific environmental exposures, plague

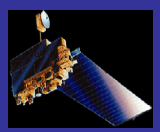
TOMS-EP, ASTER yield data on air quality, toxic exposures, urban heat island

MODIS TRMM yield new information on disease vector ecology

New weather/climate/environment-disease relationships discovered. Results applied to Environmental Public Health Tracking Network, Malaria Modeling & Surveillance, ArboNet, RSVP

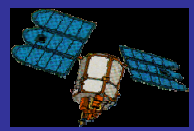
State 1-Public health surveillance systems require complete information on weather / climate / environment factors.

This roadmap depicts Incremental improvements in surveillance with discovery of new environment-disease relationships and development of predictive models. More rapid improvements will occur with integration of geospatial data and models into existing surveillance systems.


Terra

Aqua

EO-1


TOMS-EP

TRMM

NPOESS

Reduced morbidity, mortality, and healthcare costs

National public health surveillance systems with automated ingest and assimilation of Earth system science results

2002 2004 2008

January 25, 2005

Water Management

Assessments and forecasts of water supplies

State 2-AWARDs (c. 2014)
Three forecasts of precipitation and daily crop water use towards more efficient irrigation. Seasonal forecasts for optimum vegetation selection and improved water use efficiency; RiverWare & BASIN

January 12, 2004,
J. Entin

Partners

Bureau of Reclamation
Managing Water In The American West
EPA
USDA
USGS
science for a changing world

Second generation data from missions and models [e.g. snow, surface water, full column soil moisture]

Improved capability in DSS resulting from the data, predictions, information products and new science knowledge.

Incorporation of NASA's SPoRT project's weather forecasts

Improved capability of DSS to modify advice based on short term predictions (<12 hours) of nominal and severe weather events.

Seasonal Forecasts from NASA's Seasonal to Interannual Project (NSIPP)

Improved water supply and water use potential for a given area for the DSS to result in improved crop selection.

GRACE & AMSR, combined with GLDAS & LIS projects

Improved assessments of surface and sub-surface water storage and transport.

International water assessment & decision support systems enhanced.

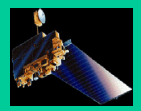
Deployment of Land Data Assimilation Systems (LDAS) and Vegetation Data Sets (from MODIS)

Additional information on current precipitation and potential crop water use statistics. Better knowledge of current crop existence (higher accuracy).

Current trajectory:
Steady improvement in water quality and quantity assessments

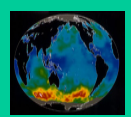
State 1- AWARDS (c. 2002), Agricultural Water Resources and Decision Support, limited to real-time rainfall and daily crop water use estimates; RiverWare & BASIN

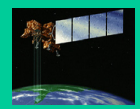
Landsat 7

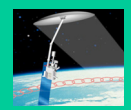

Terra

Aqua

GRACE


*GPM


LDCM
*Pre-formulation


HYDROS

*NPOESS

Snow
Surface Water

2002 2003 2004 2006 2008 2010 2012 2014

Socioeconomic Impact

An integrated decision support system assimilating models and measurements of water transport and storage.

January 25, 2005